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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

REPORT
ON THE OPERATIONS OF THE
COAL-TESTING PLANT
OF THE
UNITED STATES GEOLOGICAL SURVEY
AT THE
LOUISIANA PURCHASE EXPOSITION, ST. LOUIS, MO., 1904

PART III.—Producer-gas, Coking, Briquetting, and Washing Tests

EDWARD W. PARKER, JOSEPH A. HOLMES, MARIUS R. CAMPBELL
COMMITTEE IN CHARGE



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GOVERNMENT PRINTING OFFICE
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NOTE.

This report consists of three parts, namely:

Part I. Field work, classification of coals, chemical work (pp. 1-300).

Part II. Boiler tests (pp. 301-979).

Part III. Producer-gas, coking, briquetting, and washing tests (pp. 981-1473).

Part I contains also a general table of contents, a list of illustrations, and an introduction. An index to the report appears at the end of Part III.

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PRODUCER-GAS TESTS.

By ROBERT H. FERNALD.

INTRODUCTION.

In this report of twenty-four tests upon producer gas, the aim has been to present the information obtained in such form that those interested may readily follow the different steps of the work. As few, if any, data have been found relating to the methods of conducting producer-gas tests, it seems desirable to make this report in somewhat elaborate detail. The various operations and calculations are therefore presented with the hope that they will not only assist in an understanding of the report, but that they will invite such careful consideration and just criticism as may lead to improvements in the methods of conducting producer-gas tests.

EQUIPMENT.

The plant installed is a Taylor pressure gas producer, furnished by R. D. Wood & Co., of Philadelphia. It is known as a 250-horsepower producer-gas power plant. Pl. VIII shows the general arrangement of the plant. The boiler house, directly in the rear, was erected in connection with the boiler and steam-engine trials and is not directly connected with the producer-gas plant. At the extreme right in the view is the gas-engine room. The exhaust pipe of the gas engine is seen projecting through the roof. In figs. 104 and 105 are shown the plans and elevations of the different units of the plant, as well as the general dimensions.

In the catalogue published by R. D. Wood & Co. the specifications given for the producer are:

“Gas producer with rotative ash table; design A; size, No. 7; inside diameter of brick lining or jacket, 7 feet; area of fuel bed, 38.5 square feet; height of top of casing, 15 feet.”

The producer consists of an iron cylinder 8 feet 6 inches in internal diameter and 15 feet high. The upper part of this shell is lined with approximately 2,800 wedge fire brick, the vertical depth of this lining being 10 feet 3 inches. The space

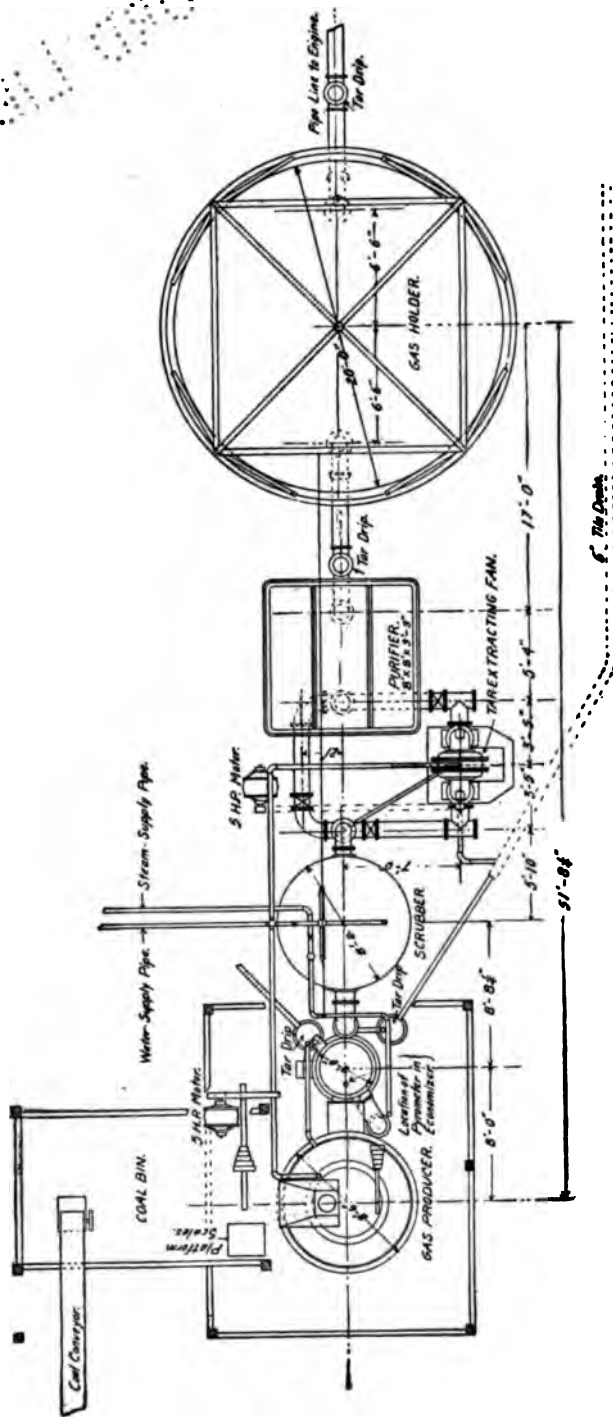


FIG. 104.—Plan of producer-gas power plant.

between the brick lining and the casing is filled with sand. Below the brick lining is a perforated conical iron bosh. This bosh extends 2 feet 1 inch below the brick lining. Its internal diameter at the bottom is 5 feet. The perforations are used as a means of breaking up the ash bed in case of the formation of clinkers. Below the bosh is a revolving ash table, which is of greater diameter than the bottom of the bosh. The ash, descending through the bosh to the revolving table, is discharged uniformly into the ash pit. If the uniform discharge of the ash is in any way prevented so that the ash bed tends to become thicker on one side than on the other, bars may be inserted just above the ash table, through apertures in the ash-pit casing, to cause a more rapid falling of the ash on that side and a consequent evening of the ash-bed depth.

As is shown in fig. 106, numerous "sight-



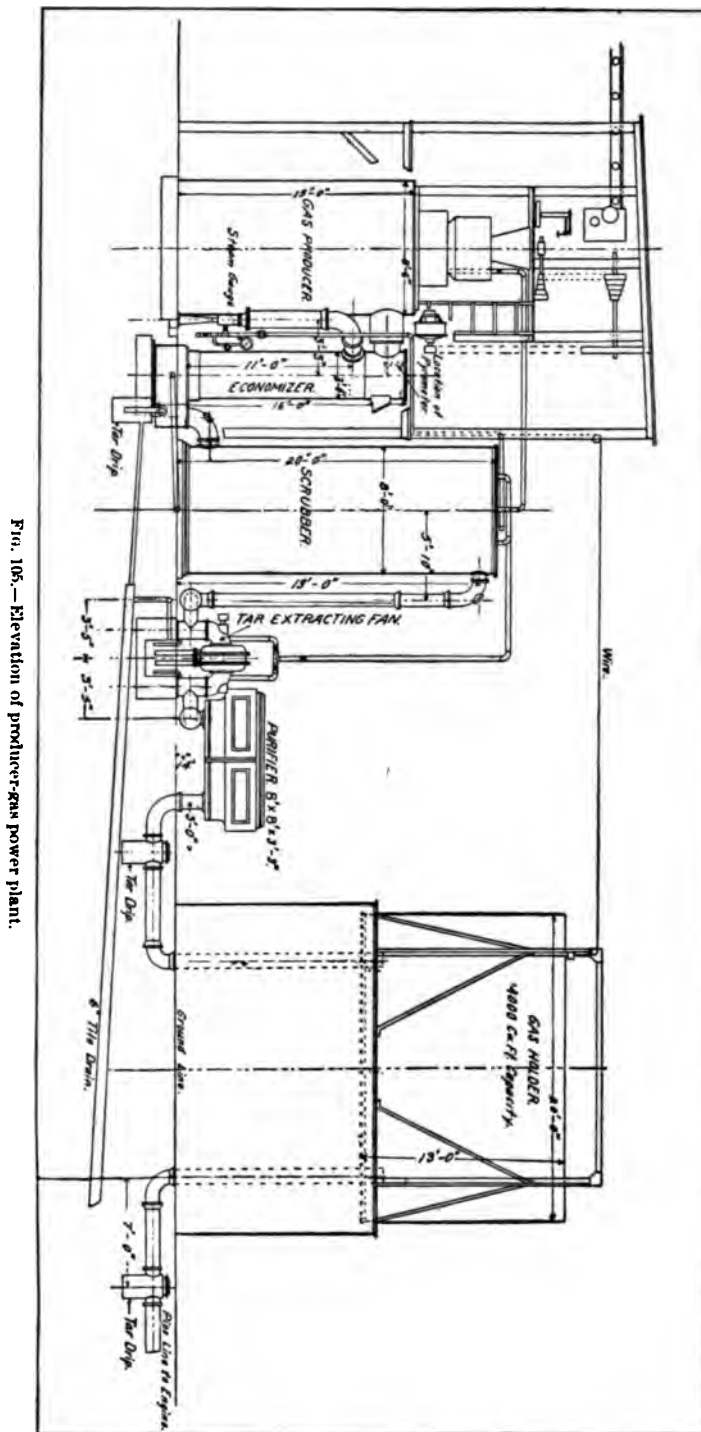
PRODUCER-GAS PLANT.

holes" are located from 5 to 6 feet above the ground level to give opportunity for frequent inspection of the conditions within the producer during operation.

The blast pipe passes through the revolving ash table and the bosh. This pipe is 7 inches in internal diameter as it enters the ash pit, but in passing through the ash table is enlarged to 10 inches. Its upper end is covered by a hood to assist in the uniform distribution of the blast. The connection of this blast pipe to the economizer is shown in fig. 105.

The blast for this producer is furnished by means of a steam jet blower, the steam being drawn from the boilers which form a portion of the equipment of the testing plant. Fig. 104 shows the connection of this steam line to the blast pipe.

Above the producer proper, as shown in fig. 106, are the coal hopper and feeding



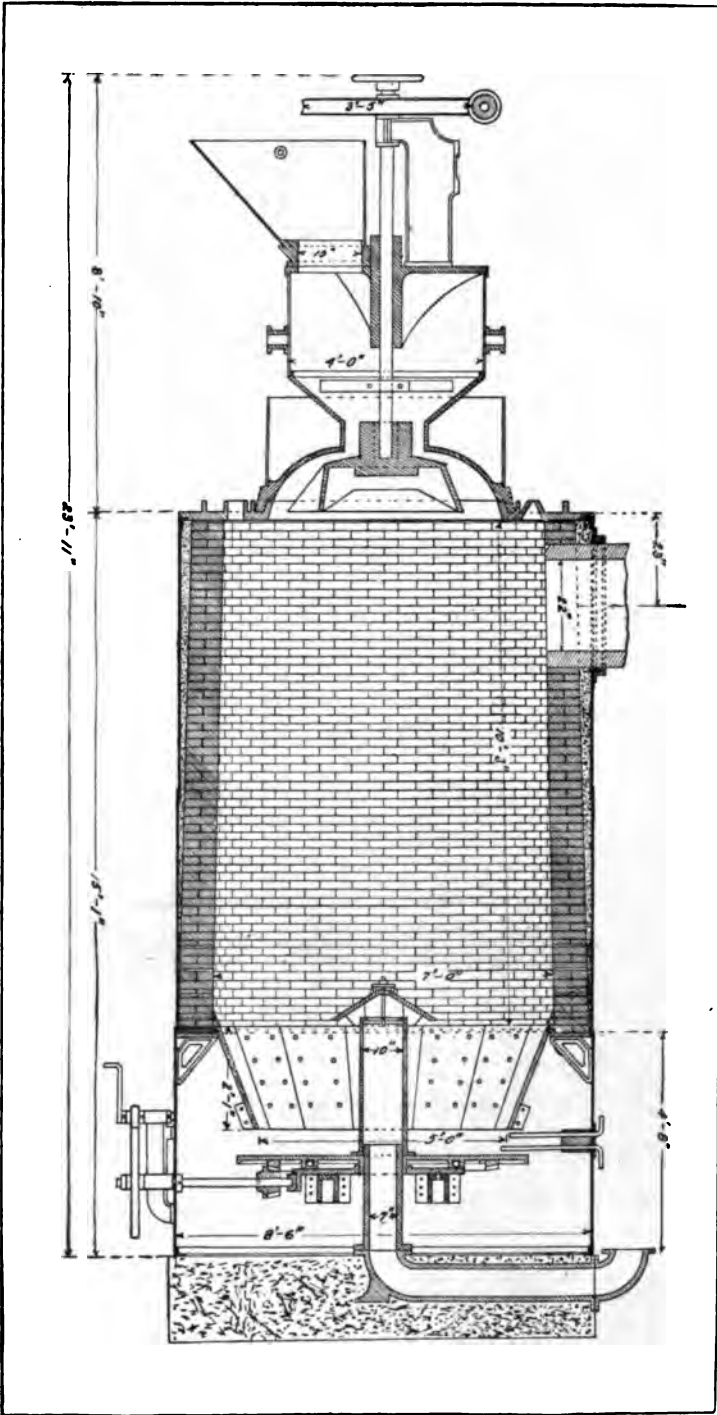


FIG. 106.—Section of gas producer.

devices. The description of these auxiliaries to the producer, as given by R. D. Wood & Co., is:

“The Bildt continuous automatic feed, as its name implies, continuously delivers the fuel in a steady shower of coal in controlled volume from the deflecting surfaces of a constantly rotating distributor. Being automatic, it eliminates any possible negligence on the part of the attendant in supplying fuel, and as it receives its supply from a closed storage magazine above the producer it avoids the serious loss of gas arising from other methods of charging. The storage magazine is of large capacity, requiring to be filled at longer intervals than usual, and then, as stated, with trifling, if any, loss of gas. Thus a great saving in fuel and labor is effected, while the comfort and health of the attendant is promoted.

* * * *

"The apparatus consists of a receiving hopper surmounting the main storage magazine, communication between the two being regulated by a horizontal rotating register or grate operated by a lever.

"Below the main magazine is suspended the distributing plate, its inclosing shield or hood, as well as the inverted conical base of the magazine, being water cooled. The influence of the cooling water and the location of the plate above the gaseous current facilitates the discharge of strongly caking coals. The distributing plate is supported by a steel shaft passing upward through the storage cylinder and suitably guided, as shown. At the upper end of the shaft, above the supporting bracket, a worm wheel and worm impart rotation to the receiving hopper, which, through its radial arms and hub keyed to the shaft, revolves the distributor. The hand-wheel nut upon the threaded end of the axis affords means of adjusting the distance between the distributing plate and the coal reservoir. By such adjustment and by variable speed (ranging from one revolution in one and one-half to one revolution in six minutes), secured through step-cone pulley, the rate of coal discharge is readily controlled.

* * * * *

"In the sides of the magazine are holes for insertion of rod or for inspection when necessary. The lower lip of the dome inclosing the distributing plate slips over the flange or rib rising from inner edge of the top plate, the joint thus formed being sealed by the water lute.

"During the operation of the producer the ash bed is carried sufficiently high (3 to 4 feet in depth above the revolving bed) to prevent contact of the incandescent coal with the iron of the bosh. This brings the line between the fuel and the ash a few inches above the hood of the blast pipe.

"In constructing this particular type of producer the object has been to secure the five following conditions:

"1. A continuous and automatic feed; the former for regularity and uniformity of gas production with improved quality, the latter for eliminating negligence of attendants.

"2. A deep fuel bed carried on a deep bed of ashes; the first to make good gas, and the second to prevent waste of fuel.

"3. Blast carried by conduit through the ashes to the incandescent fuel.

"4. Visibility of the ashes and accessibility of the apparatus for their removal, all so arranged that operator can see what he is doing.

"5. Level, grateless support for the burden, insuring uniform depth of fuel at all points, and consequent uniformity in the production of gas."

The gas leaves the producer through a 22-inch pipe, as shown in fig. 106, and passes through the economizer.

The economizer consists of an iron casing 3 feet in internal diameter and 16 feet 6 inches high, containing six 7-inch tubes.

The gas coming from the producer enters a chamber at the top of the economizer through a 21-inch pipe and then passes downward through the tubes to the water-sealed chamber, or wash box, at the base. Connected to this chamber are a

tar drip and water overflow, as shown in figs. 104 and 105. After passing into this chamber the gas goes through a 12-inch pipe directly into the bottom of the scrubber.

The air for the blast enters the economizer through slides near the bottom of the casing and passes upward, surrounding the tubes and absorbing heat from the hot gas that is passing downward through them. The heated air leaves the economizer through the 12-inch opening near the top and passes into the blast pipe, as shown in fig. 105.

The scrubber, an iron cylinder 8 feet in diameter and 20 feet in height, is filled with gas-house coke, which is constantly flushed with water during the operation of

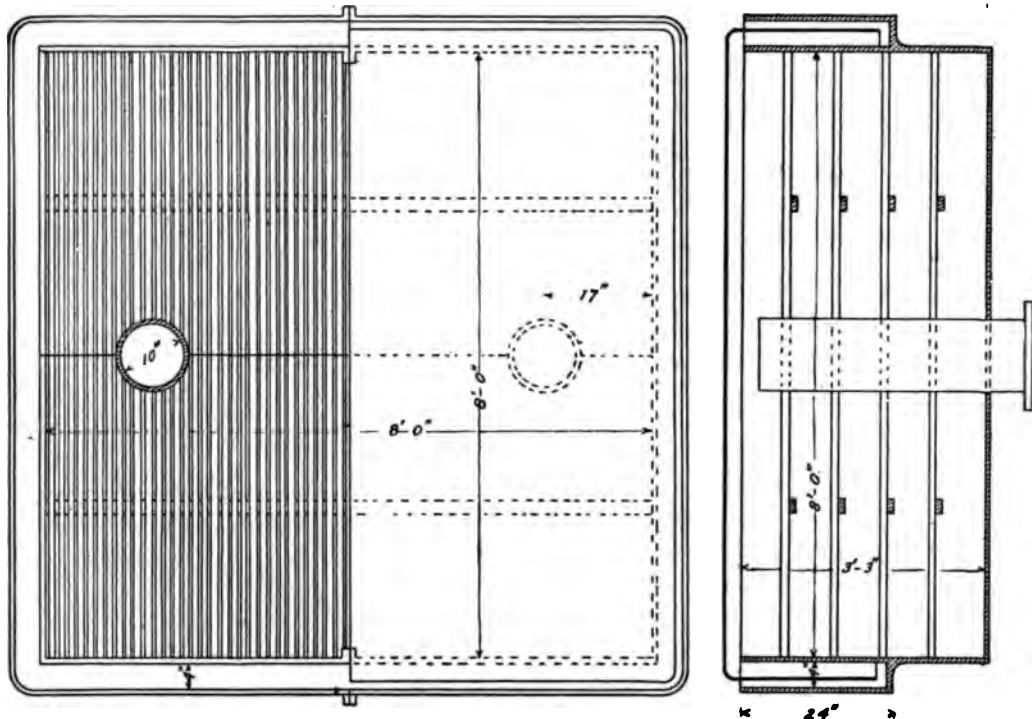


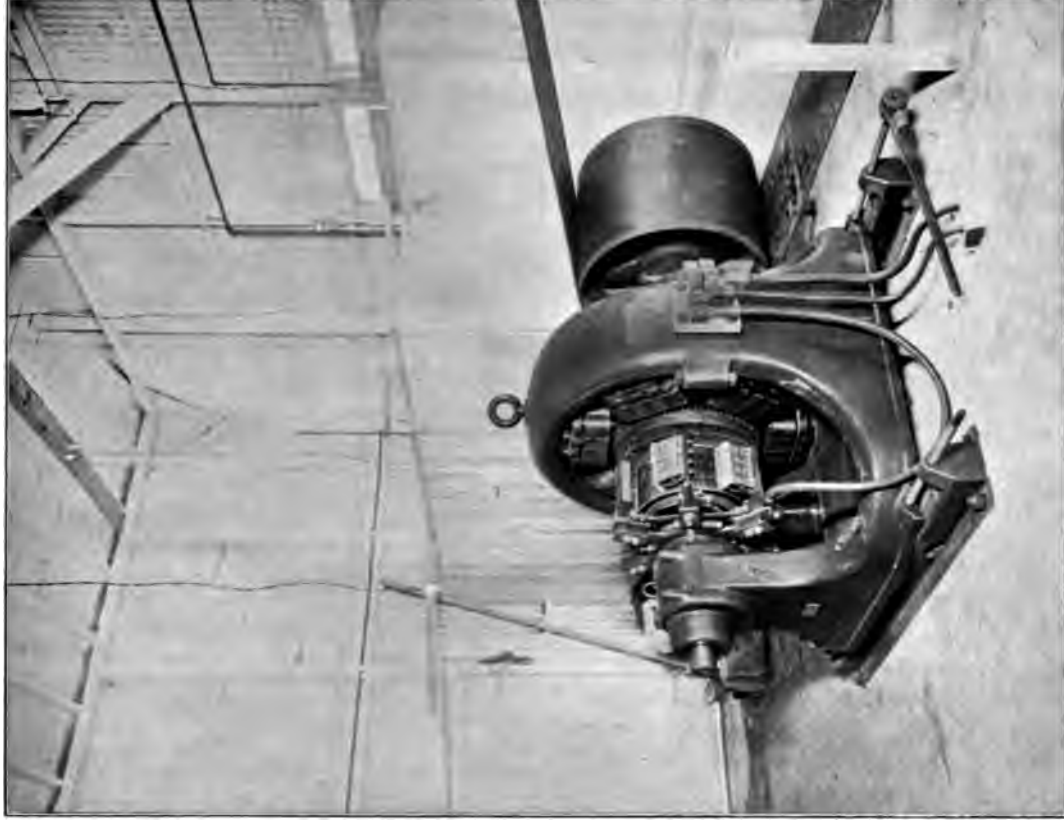
FIG. 107.—Gas purifier.

the plant. In passing through the scrubber the gas is partially cleansed before entering the tar extractor.

The details of the construction of the tar extractor are carefully guarded by the manufacturers of the producer. It resembles in outward appearance a centrifugal pump. As the gas is sent through the extractor the tar passes down through the tar drips to a water-sealed pit, from which it is easily removed. A liberal supply of water is used during this part of the process of purification. The speed of rotation of the "fan" in the tar extractor is of vital importance,



A. WESTINGHOUSE GAS ENGINE.



B. WESTINGHOUSE DIRECT-CURRENT GENERATOR.

and any deviation from the proper speed (1,500 revolutions per minute in case of the plant under consideration) seriously affects the successful working of the extractor, particularly if the variation be a reduction of speed. The "fan" in the extractor is driven by a 10-horsepower motor.

From the tar extractor the gas passes to the purifier, an iron box 8 feet square and 3 feet 3 inches in height (shown in fig. 107). This box is divided into compartments by wooden lattice frames, and is filled with oxidized iron filings and shavings for removing the sulphur from the gas.

Before reaching the holder the gas passes another tar drip, shown in figs. 104, 105.

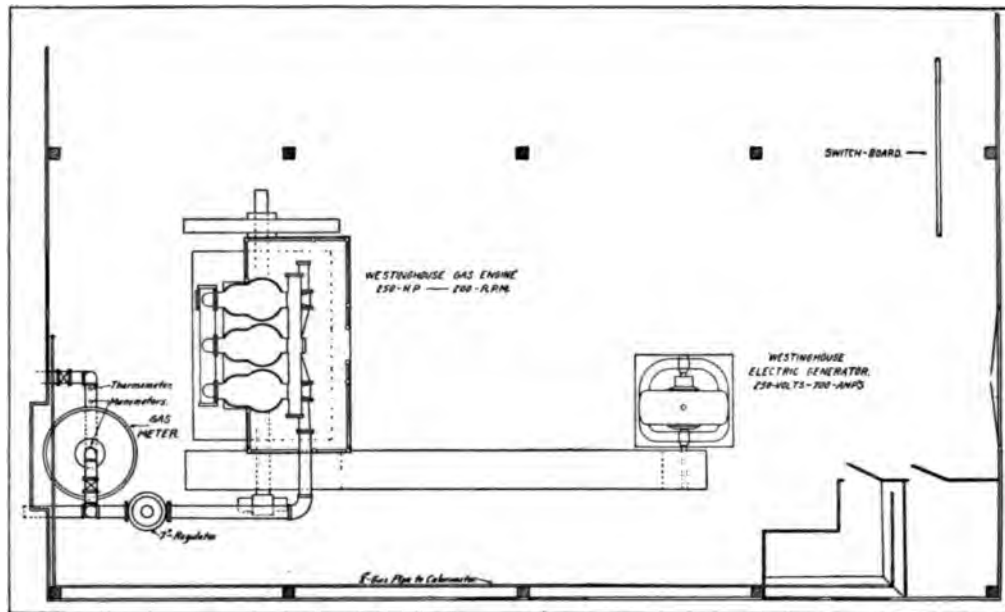


FIG. 108.—Plan of engine room of producer-gas plant.

The holder is a receiver, 20 feet in diameter and 13 feet high, of 4,000 cubic feet capacity.

Between the holder and the gas meter, on the pipe line leading to the engine, is a final tar drip for the removal of any traces of tar that may have escaped capture in the preceding drips and extractors. After going through a meter of 30,000 cubic feet per hour capacity, the gas is delivered to a three-cylinder vertical Westinghouse gas engine, as shown in the plan of the engine room, fig. 108. On the pipe line leading from the meter to the engine is a special gas regulator installed by the Westinghouse Machine Company in connection with the engine. (See Pl. X.)

The cylinders of the engine are 19 inches in diameter and 22 inches in stroke. The engine makes 200 revolutions per minute and is rated at 235 brake horsepower on producer gas.

The engine is belted to a six-pole, 175-kilowatt Westinghouse direct-current generator, as indicated in fig. 108 and as shown in Pl. IX.

The load on the generator is controlled by and the energy developed is dissipated through a water rheostat constructed especially for the purpose. In spite

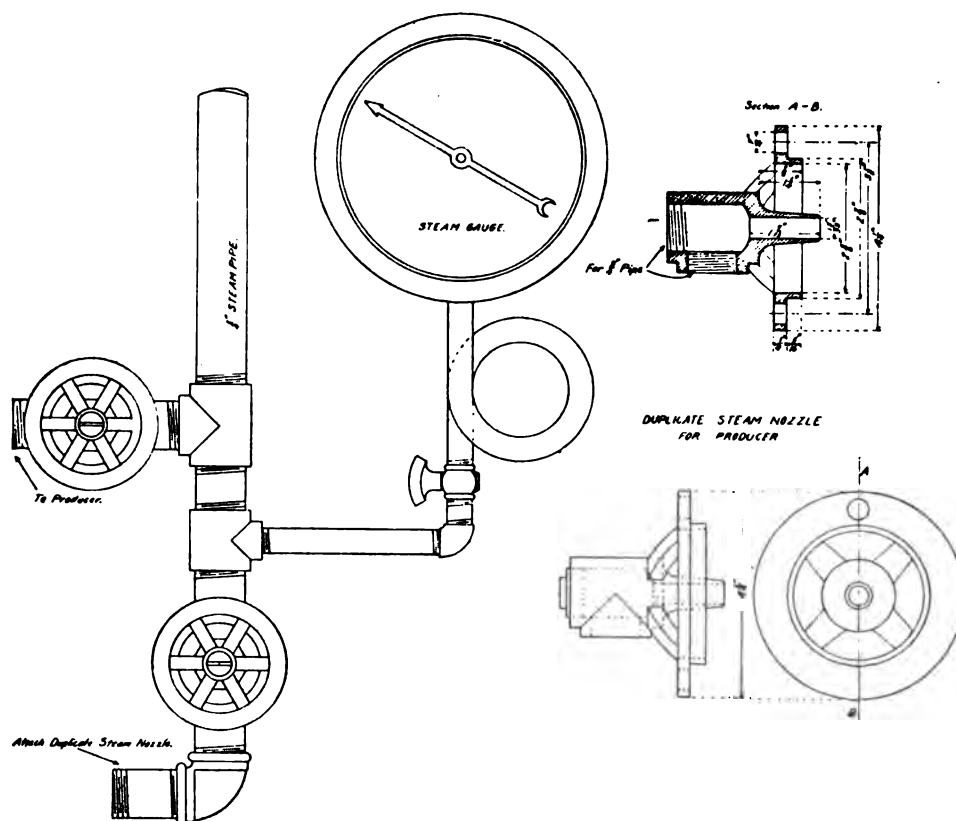
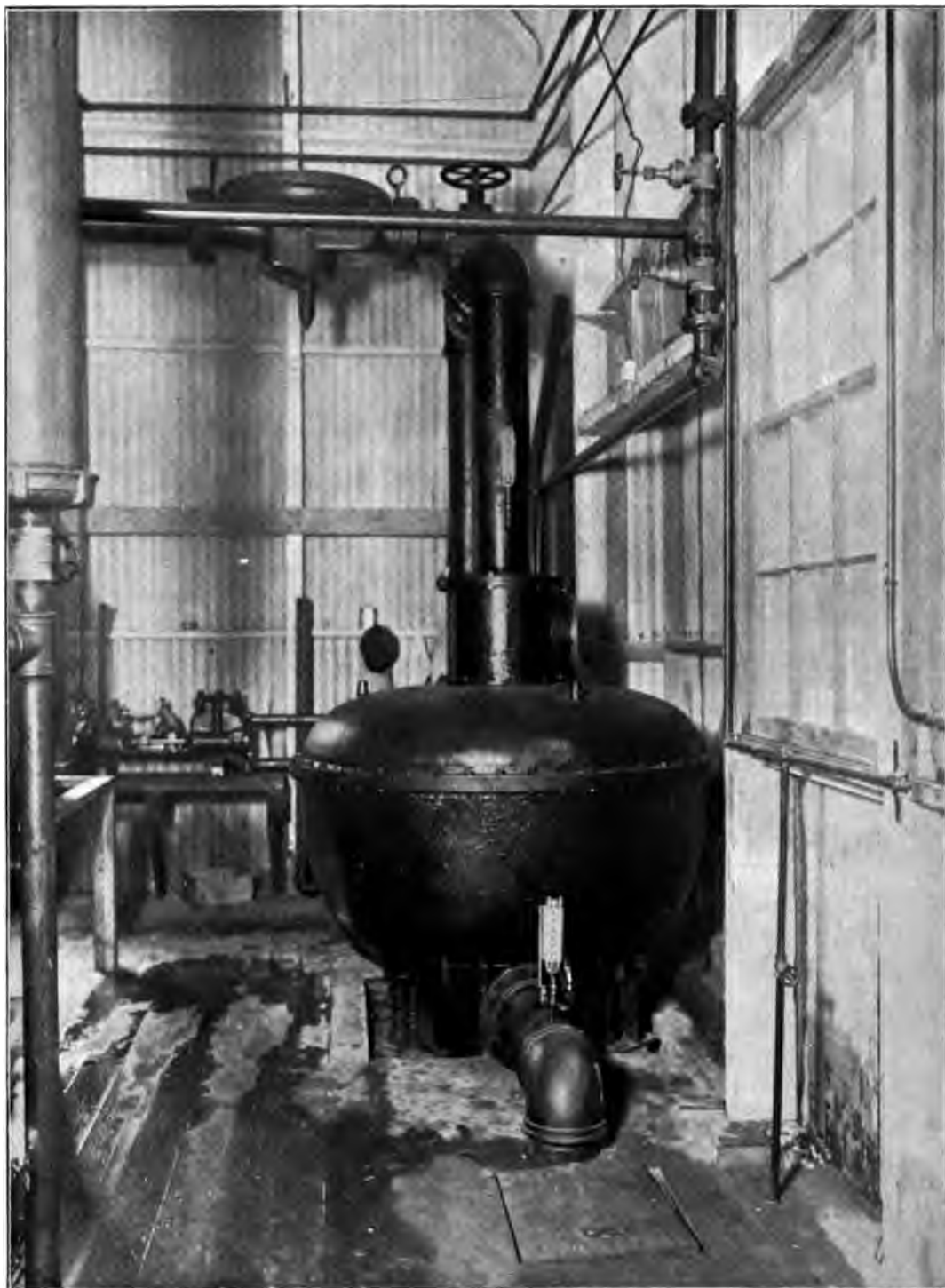


FIG. 109.—Apparatus used to determine quantity of steam used by producer.

of many predictions to the contrary, this rheostat has proved so efficient that a detailed description of its construction will be given.

As seen by Pl. VII, the rheostat is located outside the engine room, behind the switch board and about 25 feet from the generator. Of the two rheostats shown in the cut the one on the left is used in connection with the gas engine and the one on the right in connection with the steam engine. This left-hand rheostat is a box, open at the top, 8 feet 2½ inches long, 3 feet 4 inches wide,



GAS METER.

and 2 feet 6 inches high, built of 2-inch yellow pine. It is mounted on 4-inch porcelain insulators, and is lined on the inner sides and bottom with 26-gage sheet steel. Iron lugs are riveted to the top of the side plates, which are connected to the negative pole of the generator by five No. 0000 B. & S. stranded cables. The center plate is of No. 10 gage sheet steel, 28 inches by 96 inches. This is bolted to a skeleton frame made of 2 by 4 inch yellow pine. This "knife-blade" is hinged at one end, and to the other end is attached a hoisting rope, which is wound on a windlass inside of the building. Thus the "knife-blade" can be readily raised or lowered as desired. The center plate is connected to the positive pole of the generator, but the plates are prevented from coming in contact by two 2-inch insulators in the bottom of the tank.

The life of this plate is about 450,000 ampere-hours, but its construction is simple and it is easily replaced when destroyed.

When the rheostat is in operation about 500 gallons of water are carried in the tank.

Nearly all the instruments and apparatus used in connection with the tests were loaned by the manufacturers or dealers. These instruments are all of standard form, and were frequently calibrated at the National Bureau of Standards in the electricity building, World's Fair grounds.

LOG AND REPORT FORMS USED.

In arranging for the tests of the gas-producer division of the testing plant, no forms for log or report blanks could be found. It was therefore necessary to prepare such forms as would best serve the purpose at the time. These blanks, with such slight modifications as are warranted by the experience of the last few months, are presented in detail.

OPERATIONS OF THE COAL-TESTING PLANT.

Sheet No.....

Date.....

No.....

Rated capacity.....horsepower.

Car initials and No.....

Remarks

991

Sheet No.....

GAS-PRODUCER DIVISION.

Date

Test No.,...

Producer made by

Diameter (inside).....feet. **Height**.....feet.

Rated capacity.....horsepower.

Coal: General No..... Special No.....

Car initials and No.....

Height of fuel bed { start.....
 finish.....

Height of ash bed { start.....
 finish.....

Character of fire at start

Character of ash at start

Character of fire at finish

Character of ash at finish

Remarks.....

Sheet No.....

GAS-PRODUCER DIVISION.

Date.....

Test No.....

Recorded by

Producer made by

Diameter (inside).....feet. **Height**feet.

Rated capacity.....horsepower.

Coal: General No. Special No.

Car initials and No.....

.....

.....

993

Sheet No.....

Date

Test No.....

Diameter cylinders.....inches. Length of stroke inches.

Car initials and No.....

Sheet No.....

Date

Diameter of cylinders.....inches. Length of stroke.....inches.

Car initials and No

Remarks

Form G.

U. S. GEOLOGICAL SURVEY COAL-TESTING PLANT.

Sheet No.....

GAS-PRODUCER DIVISION.

Date.....

REPORT OF GAS-ENGINE TEST No.....

Recorded by

Engine made by

Type of engine.....

Rated capacity brake horsepower.

Diameter cylinders.....inches. Length of stroke.....inches.

Producer-gas test No.....

Coal: General No.....

Special No.....

Car initials and No.....

Duration of test, in hours.....

Revolutions per minute (mean).....

Explosions per minute (mean).....

Cubic feet gas per hour, by meter.....

Cubic feet standard gas per hour (i. e. 62° F., 14.7 lbs. pres.).....

Pressure at end of compression	1st cylinder	.....
	2d "	.....
	3d "	.....
Maximum pressure	1st "	.....
	2d "	.....
	3d "	.....
Pressure at release	1st "	.....
	2d "	.....
	3d "	.....
Mean effective pressure	1st "	.....
	2d "	.....
	3d "	.....
Indicated horsepower	1st "	.....
	2d "	.....
	3d "	.....

Total indicated horsepower.....

Horsepower delivered (electrical horsepower).....

Mechanical efficiency (engine and generator combined).....

Gas horsepower.....

British thermal units equivalent to indicated horsepower.....

British thermal units equivalent to brake horsepower.....

British thermal units equivalent to electrical horsepower.....

British thermal units equivalent to gas horsepower.....

Thermal efficiency, based on indicated horsepower and gas horsepower.....

Thermal efficiency, based on brake horsepower and gas horsepower.....

Thermal efficiency, based on electrical horsepower and gas horsepower.....

Cubic feet standard gas per hour per indicated horsepower.....

Cubic feet standard gas per hour per brake horsepower.....

Cubic feet standard gas per hour per electrical horsepower.....

995

Sheet No.....

GAS-PRODUCER DIVISION.

Date.....

No.....

Recorded by

Producer-gas test No*

Coal: General No..... Special No.....

Car initials and No......

[illegible]

Average barometer.....

Remarks

Form I.

Sheet No.....

U. S. GEOLOGICAL SURVEY COAL-TESTING PLANT.

GAS-PRODUCER DIVISION.

Date.....

LOG OF GAS ANALYSIS.

No.....

Recorded by

Producer-gas test No.....
Coal: General No Special No.....
Car initials and No

Per cent by volume.]

Time.						
H ₂ S.....						
CO ₂						
O ₂						
C ₂ H ₄						
CO.....						
H ₂						
CH ₄						
N.....						
Total						
Calculated British thermal units						

Remarks

Form J.

Sheet No.....

U. S. GEOLOGICAL SURVEY COAL-TESTING PLANT.

GAS-PRODUCER DIVISION.

Date.....

Report of.....
Recorded by

Producer-gas test No.....
Coal: General No Special No.....
Car initials and No

.....
.....
.....

PRODUCER-GAS TESTS.

997

Form K.

Sheet No.....

U. S. GEOLOGICAL SURVEY COAL-TESTING PLANT.

GAS-PRODUCER DIVISION.

Date.....

REPORT OF PRODUCER-GAS TEST.

No.....

Recorded by

Producer made by

Diameter.....feet. Height.....feet.

Rated capacity.....horsepower.

Coal: General No..... Special No.....

Car initials and No.....

1. Duration of test, in hours.....

AVERAGE TEMPERATURE, ° F.

2. Gas leaving producer.....

3. Gas leaving economizer.....

4. Gas entering holder.....

5. Air entering economizer.....

6. Air leaving economizer.....

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

7. Total steam used by producer, pounds.....

8. Steam used by producer per hour, pounds.....

9. Equivalent in pounds of coal per hour.....

10. Equivalent in pounds of dry coal per hour.....

11. Equivalent in pounds of combustible per hour.....

12. Average horsepower required to drive auxiliary machinery.....

13. Total water used in scrubber and tar extractor, cubic feet.....

14. Cubic feet of water per hour per horsepower of producer plant.....

15. Cubic feet of water per 1,000 cubic feet of gas produced.....

COAL CONSUMED IN PRODUCER.

16. Total coal consumed, pounds.....

17. Moisture in coal, per cent.....

18. Total dry coal consumed, pounds.....

19. Refuse from coal, per cent.....

20. Total refuse from coal, pounds.....

21. Total combustible consumed, pounds.....

COAL PER HOUR.

22. Coal consumed in producer, pounds.....

23. Dry coal consumed in producer, pounds.....

24. Combustible consumed in producer, pounds.....

25. Equivalent coal used by producer plant, pounds.....

26. Equivalent dry coal used by producer plant, pounds.....

27. Equivalent combustible used by producer plant, pounds.....

Form L.

U. S. GEOLOGICAL SURVEY COAL-TESTING PLANT.

Sheet No.....

GAS-PRODUCER DIVISION.

Date.....

REPORT OF PRODUCER-GAS TEST (Continued).

No.....

Recorded by

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

- 28. Coal as fired
- 29. Dry coal
- 30. Combustible.....

BRITISH THERMAL UNITS FROM COAL.

- 31. Per pound of coal as fired
- 32. Per pound of dry coal
- 33. Per pound of combustible.....
- 34. From coal as fired, per hour.....
- 35. From dry coal, per hour.....
- 36. From combustible, per hour.....

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

- 37. Total
- 38. Per hour.....
- 39. Per pound coal consumed in producer.....
- 40. Per pound dry coal consumed in producer.....
- 41. Per pound combustible consumed in producer.....
- 42. Per pound equivalent coal used by producer plant
- 43. Per pound equivalent dry coal used by producer plant.....
- 44. Per pound equivalent combustible used by producer plant.....

BRITISH THERMAL UNITS FROM STANDARD GAS.

- 45. Per cubic foot
- 46. Per pound dry coal burned in producer.....
- 47. Per hour per brake horsepower

AVERAGE HORSEPOWER DEVELOPED.

- 48. Electrical horsepower available for outside purposes
- 49. Electrical horsepower developed at switch board.....
- 50. Brake horsepower available for outside purposes
- 51. Brake horsepower developed at engine

EFFICIENCIES.

- 52. Of conversion and cleaning gas
- 53. Of producer plant

PRODUCER-GAS TESTS.

999

Form M.

Sheet No.....

U. S. GEOLOGICAL SURVEY COAL-TESTING PLANT.

GAS-PRODUCER DIVISION.

Date.....

REPORT OF PRODUCER-GAS TEST (Continued).

No.....

Recorded by

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes			
55. Pounds consumed in producer per electrical horsepower developed at switch board			
56. Pounds consumed in producer per brake horsepower available for outside purposes			
57. Pounds consumed in producer per brake horsepower developed at engine			
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes			
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board			
60. Equivalent pounds used by producer plant per brake horsepower available for outside purposes			
61. Equivalent pounds used by producer plant per brake horsepower developed at engine			

AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal.	Per cent.	63. Gas by volume.	Per cent.
Moisture		Hydrogen disulphide (H ₂ S)	
Volatile matter		Carbon dioxide (CO ₂)	
Fixed carbon		Oxygen (O ₂)	
Ash		Ethylene (C ₂ H ₄)	
		Carbon monoxide (CO)	
		Hydrogen (H ₂)	
		Methane (CH ₄)	
		Nitrogen (N ₂)	
Sulphur			

PERSONNEL.

During the first few weeks the gas producer was operated under the direct supervision of Mr. C. W. Lummis, a representative of R. D. Wood & Co. Mr. Lummis was followed by Mr. C. O. Nordensson, also from R. D. Wood & Co., who continued in charge of the operations of the producer until the close of the tests. The gas engine has been run by Mr. J. G. Culbertson, a representative of the Westinghouse Machine Company.

The observations and computations have been made by a crew of college men, who have been trained in various technical institutions and who have supplemented this training with practical experience. The men employed in these two important

departments are Messrs. R. W. Cummings, H. G. Ecker, H. A. Grine, M. H. Mount, R. E. Peshak, Kurt Toensfeldt, and W. C. Weidmann.

A double-check system has been maintained throughout all computations, thus assuring a high degree of accuracy. The operating supervision of the tests has been under the direct control of Capt. John A. Laird, a consulting engineer of St. Louis.

CONDITIONS OF CONDUCTING TESTS.

The tests were begun on a basis of a total of fifty hours for each test. The plant was operated ten hours a day and then fires were banked for the night, the records being continued the next morning. This permitted one test a week only. With the small crew at command it seemed to be the best possible arrangement and was continued for the first two tests. It was then thought desirable to secure double the number of tests, and the schedule was arranged to conduct two tests per week, each of thirty consecutive hours, allowing sufficient time between tests to make the necessary change of fuel and to enable the fuel bed in the producer to be brought to a proper working condition.

As it was desired to test as many coals as possible during the few weeks remaining before the close of the exposition, the highest possible economy was made a secondary consideration, and for a part of the time the plant was run with a leaky hopper and other unfortunate conditions, which naturally impaired its efficiency.

In comparing the results it should be borne in mind that in these preliminary tests the object has been to demonstrate the possibility of using these coals in a producer, and not to show how efficiently they could be burned. Although the results in many cases have been highly satisfactory, there is no question that in a second series of tests upon the same coals, made with the idea of showing the greatest economy, the amount of coal used per horsepower per hour will, in the majority of cases, be much less.

During tests Nos. 5 to 14, inclusive, the hopper of the gas producer leaked, and considerable gas was wasted, thus vitiating to a small but undetermined extent the efficient results that might otherwise be shown for the coals tested during that period. But at the time of making these tests it was not practicable to stop the operations of the plant for repairs; and the main purpose of the preliminary tests being to determine whether the coals were suitable for producer-gas purposes, it was decided to proceed, in spite of the leak in the hopper, and to repeat later, under more favorable conditions, the tests for relative efficiency.

Immediately after the close of the exposition, it having been decided to continue the tests for some weeks longer, the plant was shut down in order to repair the leaking hopper and to prepare for cold weather. Operations were

resumed on December 12 and continued to December 22, when a holiday recess was taken. After the recess the tests were continued through the month of January. In all, twenty-four producer-gas tests were made during the period from the 1st of October to the 1st of February.

DETAILS OF LOG OF TEST.

On examining the logs of the twenty-four tests which form the basis of this report it will be noticed that some of the items of minor importance called for in the standard log sheets, shown on pages 989 to 998, have been omitted. These omissions were found necessary in these preliminary tests, and the unused columns of the log sheets have consequently been dropped in tabulating the data obtained from these twenty-four tests.

In order to make the methods employed in conducting these tests perfectly clear, it is deemed wise to take up each item of the log and report in detail. The analysis of the log sheets, item by item, is presented below.

Item 1.^a Time.—In order to insure accuracy in the records the time interval between readings was made short. Although the tests were several hours in duration, the interval between readings has been twenty minutes.

Item 2. Coal fired.—The coal for use in the producer was delivered to a platform above the producer by a Robins belt conveyor. The coal was then weighed on Fairbanks scales in uniform lots of 300 pounds, as required by the producer operator.

A covered metal sampling can was kept on the platform and a small shovelful of coal from each weighing was thrown into this can. At the close of a thirty-hour run this sample amounted to about 100 pounds. The sample was then mixed and quartered twice, about 25 pounds being sent to the chemical laboratory for analysis: (For details of this work see Prof. N. W. Lord's report, p. 174.)

Item 3. Gas-meter readings.—The gas meter used was furnished by the Pittsburgh Meter Company. Its capacity was 30,000 cubic feet per hour. Readings were taken every twenty minutes. The meter was calibrated by comparing the meter reading with that of the gas holder, which had been carefully measured.

Item 4. Temperature of gas at meter.—Reference to Pl. X will show the location of the thermometer in the 6-inch gas main at the entrance to the meter. This thermometer, as well as all the other thermometers about the plant with the exception of those used at the gas calorimeter, was furnished by the Hohmann & Maurer Manufacturing Company.

^aThe numbers of the items correspond to those appearing at the heads of columns in the logs of tests.

Item 5. Water-meter reading.—The quantity of water used in the scrubber and tar extractor was determined as a matter of curiosity and interest only, but has taken no part in the results of the tests.

Items 6, 7. Manometers, Nos. 1 and 2.—In order to determine the pressure under which the gas flowed through the meter, manometers were placed as shown in fig. 108 (p. 987), and in Pl. X. No. 1 was located in the short horizontal pipe and recorded the pressure of the gas before entering the meter. No. 2 was placed in the vertical pipe just above the meter and indicated the pressure on the delivery side of the meter. This manometer, No. 2, stood between the meter and the engine. The pressure in both cases was read in inches of water.

Item 8. Watt meter.—The watt meter was used for recording the output required by the auxiliary motors used in operating the plant. One motor was used for running the automatic fuel feed of the producer and the other for operating the tar extractor.

Item 9. Ammeter.—As a check on the watt meter, and for use in emergencies when the watt meter was out of order, an ammeter was placed on the line running to the auxiliary motors.

The voltage was taken from the main-line voltmeter, as indicated in item 12.

Items 10, 11. Speed counters.—During the early tests two Veeder speed counters were attached to the arms which operate the admission valves. As the admissions, in case of the engine used, are positive, the counters recorded the number of admissions, or one-half the number of revolutions of the engine. Later in the season a special Schaefer & Budenberg speed counter with electrical attachments was installed. The inconvenience of climbing to the top of the engine every twenty minutes was thus avoided, as the wires were so run that the electrical counter could be located in the office.

Items 12, 13. Volts; amperes.—A Weston portable voltmeter and a Westinghouse ammeter were used to determine the electrical output of the Westinghouse generator operated by the gas engine. These were read every twenty minutes.

Item 14. Temperature of the gas leaving the producer.—This temperature was recorded by a Le Chatelier pyrometer.

Items 15, 16. Manometers.—The pressure of the air entering the producer was measured in inches of mercury. That of the gas leaving the producer was measured in inches of water. These two readings were taken as a matter of record and interest rather than for use in the immediate deductions made in the report.

Items 17, 18, 19. Temperatures at calorimeter.—The calorimetric determinations for the gas were made by means of a Junker calorimeter. The temperature of the gas entering the calorimeter was taken at the meter used with the calorimeter. The temperatures of the inlet and outlet water were taken at the places provided for

these readings in the construction of the calorimeter by means of thermometers supplied with the apparatus.

Item 20. Cubic centimeters of water collected.—The water passing through the calorimeter was delivered to and measured in the graduated glass provided with the calorimeter.

Item 21. Cubic feet of gas.—The gas passing through the calorimeter was measured by means of a Goodwin experimental meter, supplied by the American Meter Company. This meter reads to 0.001 cubic foot.

Item 22. B. T. U., as read.—The following method was employed for determining the British thermal units from the records of the Junker calorimeter:

Multiply the difference between the temperatures ($^{\circ}$ C.) of the outlet and inlet water by the number of cubic centimeters of water collected in a given time. Divide this result by the number of cubic feet of gas passing through the meter in the same time. The result is the number of calories per cubic foot of gas at the time of the readings. To convert the result into British thermal units, multiply the number of calories by 3.968.

Expressed in terms of the corresponding items the formula is:

$$\frac{(\text{Item 19} - \text{item 18}) \times \text{item 20}}{\text{item 21}} \times 3.968 = \text{British thermal units.}$$

The water of condensation was not taken into account in these determinations.

Item 23. B. T. U. standardized.—For uniformity in the readings and for comparison it is important to express the heat value of the gas in terms of a standard. The values obtained as indicated in item 22 were all corrected to correspond to the specifications of standard gas, viz, gas at 62° F. and 14.7 pounds pressure.

Let

T_g = absolute temperature of gas = t_g° F. + 459° .

v_g = cubic feet of gas at t_g° F.

p_g = pressure under which gas is flowing

= 14.7 pounds + pressure shown by manometer.

T_s = 62° + 459° = 521° F., absolute temperature of standard gas.

p_s = 14.7 pounds per square inch = atmospheric pressure.

v_s = cubic feet of standard gas.

Then

$$v_s = v_g \frac{p_g}{p_s} \frac{T_s}{T_g}$$

The results obtained in item 22 were corrected by dividing by the values of v_s obtained from the above formula, v_g being 1.

In order to reduce the labor of the large number of calculations necessary for any one test, in which readings are taken every twenty minutes for thirty or more hours, the accompanying chart (fig. 110) was used. The factors by which

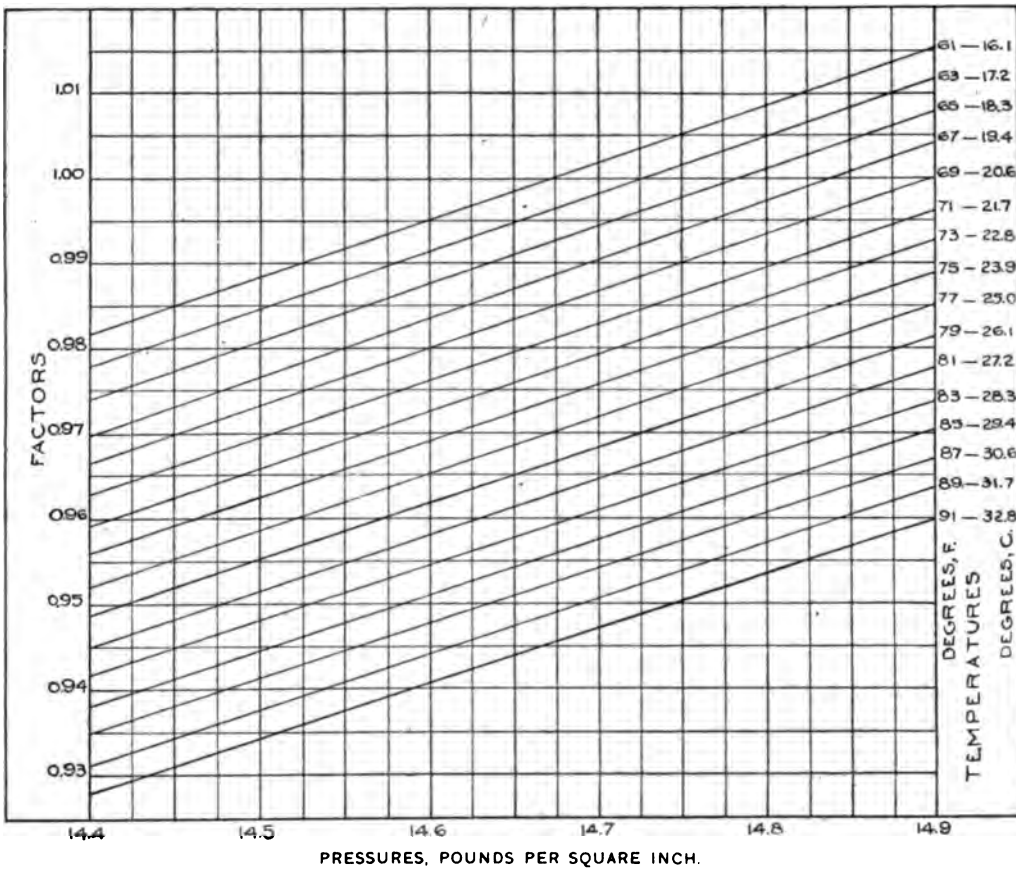


FIG. 110.—Diagram showing factor for determining cubic feet of standard gas produced.

the results of item 22 are to be divided were computed for a reasonable range of temperatures and pressures and platted as indicated.

GAS ANALYSES.

The gas analyses were made by standard methods. Hempel pipettes were used for absorption. The hydrogen (H₂) and methane (CH₄) were found by explosion over mercury. Nitrogen was obtained "by difference." The gas samples were collected in glass sample tubes, made to contain about 225 cc. of gas.

The British thermal units from the gas analyses were figured as follows from factors obtained from most reliable sources:

CO.....	3.49 B. T. U. per cc.
CH ₄	10.65 B. T. U. per cc.
H ₂	3.48 B. T. U. per cc.

For a sample of gas containing the following percentages by volume the results would be as shown:

CO..... 16.8 per cent.	For CO..... $16.8 \times 3.49 = 58.63$ B. T. U.
CH ₄ 6.1 per cent.	CH ₄ $6.1 \times 10.65 = 64.96$ B. T. U.
H ₂ 5.5 per cent.	H ₂ $5.5 \times 3.48 = 19.14$ B. T. U.

Calculated B. T. U. = 142.73

In the foregoing tests all hydrocarbons have been determined and figured as methane. Small amounts of ethylene that may occur in the gas have in this way been figured as methane, and the calorific values of the gas have been thus slightly decreased. It was deemed inadvisable to attempt the determination of ethylene by means of fuming sulphuric acid, owing to the fact that the laboratory provided for these determinations was so small that acid could not satisfactorily be used. Bromine was tried for the ethylene absorption, but was found to be of no value, owing to the small amounts of this gas present.

The difficulties encountered in attempting accurate calorimetric determination, have been so great that it seems wise to call attention to those that are most likely to be met in producer-gas plants using bituminous coals and lignites.

Variations in the gas pressure are very likely to cause inaccuracies. This is particularly true if the connections leading to the calorimeter are so arranged that the flow of gas is affected by the demands of the engine. Under these conditions in extreme cases, when the calorific power of the gas is very low and the engine is drawing an increased amount of gas, it is possible for the pressure in the pipe leading to the calorimeter to become so reduced that the flame will be put out.

Another difficulty that must be guarded against in case of gas from bituminous coals is the possibility of a slight deposit of tarry matter on the axle of the meter drum. When the meter used is small, as it naturally is for calorimetric work, a very slight deposit upon the axle will decrease the speed, thus causing inaccuracy.

Sulphur in the gas will attack and destroy the copper drums of meters, thus tending to cause inaccuracy in the readings.

DETAILS OF REPORT OF TEST.

In order to make the 63 items listed in the reports of the producer-gas tests as clear as possible, an explanation of each item is given and the method of deriving these results is shown in detail for test No. 16. This test (No. 16) was made December 16 and 17, 1904, on "Wyoming No. 2." The condensed log sheets and reports will be found on pages 1305-1313.

Item 1. Duration of test, in hours.—(See "Conditions of conducting tests," p. 1000.)

*Item 2. Temperature of gas leaving producer ($^{\circ}\text{F}$).—*This temperature was read by means of a Le Chatelier pyrometer. The tube was inserted in the top of the economizer. The wires from the pyrometer were extended to the office, about 75 feet away, and were there connected to the galvanometer. The temperature readings from the galvanometer were made every hour.

The galvanometer used was read in degrees Centigrade, and reduction was made to degrees Fahrenheit, by the familiar rule, viz: $^{\circ}\text{F} = ^{\circ}\text{C} \cdot \frac{9}{5} + 32^{\circ}$.

Example (test No. 16): The average of the pyrometer readings, as given in column 14 of the log, is 360°C ., hence,

$$^{\circ}\text{F} = \frac{9}{5}360 + 32 = 680^{\circ}.$$

Items 3, 4, 5, and 6. Temperatures.—By special request of R. D. Wood & Co. the particular temperatures indicated in items 3, 4, 5, and 6 were not taken during these preliminary tests. These items cover the temperatures of gas leaving economizer, gas entering holder, air entering economizer, and air leaving economizer.

Items 7 and 8. Steam used by producer (pounds).—Steam used for creating the blast, as indicated in the description of the producer, page 981, was supplied by the boilers used in connection with the evaporation tests of the boiler division of the coal-testing plant.

During the intervals in which the producer was not in active operation for official test purposes, several experiments were made to determine the amount of steam used by the producer per hour under gage pressures of 10, 20, 25, 30, 35, and 40 pounds. The steam gage from which these pressures were read was located as shown in fig. 105 (p. 983).

A hose attached to the steam pipe just below the gage was connected to a special nozzle, a duplicate of the one used for regulating the flow of steam in the draft pipe of the producer. The details of this nozzle and attachments are shown in fig. 109 (p. 988). The steam flowing through this test nozzle was delivered to a tank partially filled with cold water. The weight of the tank and cold water was taken before the steam was turned into the tank, and the amount of steam condensed was determined by the increase in weight shown by the scales for a given time interval. In this manner the nozzle was calibrated for the different steam pressures indicated.

During a test the pressures indicated by the steam gage show great variations, depending upon the operating conditions of the producer. There are periods when the steam is entirely shut off. These may be followed rapidly by a demand for steam at a reasonably high pressure, and this demand may in turn be followed by a corresponding drop or increase in pressure, as the case may be. It may readily be seen that the fluctuations in this steam pressure, and consequently in the quantity of steam

used during any given interval, are great, and it is therefore somewhat difficult to determine the amount of steam used by the producer with the degree of accuracy desired.

During each test two or three sets of readings of the pressures indicated by the steam gage were taken. The readings were taken at intervals of one-half minute and continued for one-half hour.

It is not improbable that a recording pressure gage may give somewhat more accurate results than the method employed. At least the record would be obtained for the entire period of the test. The introduction of a recording gage would undoubtedly tend to eliminate erratic or careless manipulation of the blast, and in this way might improve the efficient operation of the producer as well as serve the purpose for which it was primarily intended.

Item 9. Equivalent in pounds of coal per hour.—The number of pounds of coal per hour equivalent to the steam consumed by the producer is obtained by dividing the number of pounds of steam used per hour by the number of pounds of water actually evaporated by each pound of the special coal used for the producer-gas test under consideration.

As nearly all of the coals tested in the gas producer were also tested under the boilers, and as the steam for the producer blast was furnished by these same boilers, the evaporation factor has been taken directly from the records of the steam tests.

In the few cases in which no steam test was made with the coal used in the producer the coal equivalent of the steam used was determined either by comparison of the chemical analysis of the coal with that of a similar coal or by assuming the average value of the coal equivalent obtained from all the other tests to give a fairly correct percentage.

*Data given.**Solution.*

E=actual evaporation per pound of coal. (From boiler test.)

$$C_s = \frac{S}{E}$$

S=pounds of steam used by producer blast per hour=item 8.

To find:

C_s =equivalent in pounds of coal per hour.

Example (test No. 16):

E=4.4 pounds.

S=249 pounds.

$$C_s = \frac{249}{4.4} = 56.5 \text{ pounds.}$$

Item 10. Equivalent in pounds of dry coal per hour.—

<i>Data given.</i>	<i>Solution.</i>
C_s =equivalent in pounds of coal per hour=item 9.	$D_s=(100-M)\times C_s$
M =per cent moisture in coal as given in report of chemist. (See item 62.)	
To find:	
D_s =equivalent in pounds of dry coal per hour.	
Example (test No. 16):	
C_s =56.5 pounds. (From item 9.)	$D_s=(100-9.44)\times 56.5=51.2$ pounds.
M =9.44 per cent. (See item 62.)	

Item 11. Equivalent in pounds of combustible per hour.—

<i>Data given.</i>	<i>Solution.</i>
D_s =equivalent in pounds of dry coal per hour=item 10.	$B_s=(100-r)\times D_s$
r =per cent refuse on basis of dry coal as given in report of chemist.	
To find:	
B_s =equivalent in pounds of combustible per hour.	
Example (test No. 16):	
D_s =51.2 pounds. (From item 10.)	$B_s=(100-22.9)\times 51.2=39.5$ pounds.
r =22.9 per cent. (From chemist's report.)	

*Item 12. Average horsepower required to drive auxiliary machinery.—*As indicated in the explanation of the log (item 8, p. 1002), a watt meter was used for determining the horsepower required by the motors used in the operation of the plant. Readings were taken every hour.

<i>Data given.</i>	<i>Solution.</i>
W_1 =reading of watt meter at beginning of test.	$H. P.=\frac{F(W_2-W_1)}{746\times I}$
W_2 =reading of watt meter at end of test.	
F =factor of watt meter as marked on the instrument	
=4 for watt meter used.	
I =time interval in hours between readings W_1 and W_2 .	
746=constant=relation between horsepower and watt hours.	
To find:	
$H. P.$ =horsepower required to drive auxiliary machinery.	
Example (test No. 16):	
W_2 =786930.	$W_2-W_1=91680$
W_1 =695250.	$H. P.=\frac{91680\times 4}{746\times 30}=16.4$
I =30 hours.	

*Item 13. Total water used in scrubber and tar extractor.—**Data given.* W_1 =reading of water meter at beginning of test. W_2 =reading of water meter at end of test.

To find:

 W_t =total water used, cubic feet.*Solution.*

$$W_t = W_2 - W_1$$

During test No. 16 the water meter was frozen.

*Item 14. Cubic feet of water per hour per horsepower of producer plant.—**Data given.* W_t =total water used, cubic feet=item 13. $H. P.$ =horsepower of producer plant=250. H =duration of test in hours.

To find:

 W_h =cubic feet of water per hour per horsepower of producer plant.*Solution.*

$$W_h = \frac{W_t}{250 \times H}$$

*Item 15. Cubic feet of water per 1,000 cubic feet of gas produced.—**Data given.* W_t =total water, cubic feet=item 13. G =total gas produced, cubic feet=item 37.

To find:

 W_g =cubic feet of water per 1,000 cubic feet of gas produced.*Solution.*

$$W_g = \frac{1,000 W_t}{G}$$

*Item 16. Total coal consumed, pounds.—*The total coal consumed in the producer during a test is the total shown in item 2 of the log as indicated on page 1001.

Example (test No. 16): Total coal consumed=12,100 pounds= C .

*Item 17. Moisture in coal, per cent.—*This value is taken from the chemist's report of the analysis of the coal. (See item 62.)

Example (test No. 16): Moisture in coal=9.44 per cent= M .

*Item 18. Total dry coal consumed, pounds.—**Data given.* C =total coal consumed, pounds=item 16. M =moisture in coal, per cent=item 17.

To find:

 D =total dry coal consumed, pounds.*Solution.*

$$D = (100 - M) \times C.$$

Example (test No. 16):

 C =12,100 pounds=item 16. M =9.44 per cent=item 17.

$$D = (100 - 9.44) \times 12,100 = 10,957.8 \text{ pounds.}$$

Item 19. Refuse from coal, per cent.—Investigation tended to show that there was little if any partially burned or unburned coal in the ash deposited at the base of the producer. Owing to the depth of ash bed carried in the producer, the ash from any given coal is not available for inspection for several days after the coal has been fired. Although sufficient time was allowed for the complete consumption of a previously fired coal before beginning the test of a new coal, yet the different coals charged to the producer followed each other with such rapidity that the ash bed was, of necessity, made up of the refuse from several different coals.

The amount of coal passing through the producer unburned is so small that the per cent of refuse can be taken, without sensible error, directly from the chemist's report. As a matter of convenience this value was furnished by the chemist on the basis of dry coal.

For test No. 16 the refuse on a dry coal basis = 22.9 per cent = r .

Item 20. Total refuse from coal, pounds.—

Data given.

Solution.

D = dry coal consumed, pounds = item 18.

$R = r \times D$.

r = per cent of refuse = item 19.

To find:

R = total refuse, pounds.

Example (test No. 16):

$D = 10,957.8$ pounds = item 18.

$R = .229 \times 10,957.8 = 2,509.3$.

$r = 22.9$ per cent = item 19.

Item 21. Total combustible consumed, pounds.—Item 21 = item 18 — item 20.

Example (test No. 16): $10,957.8 - 2,509.3 = 8,448.5$ pounds.

Item 22. Coal consumed in producer per hour, pounds.—Item 22 = item 16 $\div$ item 1.

Example (test No. 16): $\frac{12,100}{30} = 403.3$ pounds.

Item 23. Dry coal consumed in producer per hour, pounds.—Item 23 = item 18 $\div$ item 1.

Example (test No. 16): $\frac{10,957.8}{30} = 365.3$ pounds.

Item 24. Combustible consumed in producer per hour, pounds.—Item 24 = item 21 $\div$ item 1.

Example (test No. 16): $\frac{8,448.5}{30} = 281.6$ pounds.

Item 25. Equivalent coal used by producer plant per hour, pounds.—In this item both the coal consumed in the producer and the steam used for the blast

have been charged against the producer plant. The steam used has been converted into its equivalent in coal as explained under item 9, and the sum of the coal consumed in the producer and this steam equivalent is designated "Equivalent coal used by producer plant." Item 25=item 22+item 9.

Example (test No. 16): $403.3+56.5=459.8$ pounds.

Item 26. *Equivalent dry coal used by producer plant per hour, pounds.*—Item 26=item 23+item 10.

Example (test No. 16): $365.3+51.2=416.5$ pounds.

Item 27. *Equivalent combustible used by producer plant per hour, pounds.*—Item 27=item 24+item 11.

Example (test No. 16): $281.6+39.5=321.1$ pounds.

Item 28. *Coal, as fired, consumed per square foot of fuel bed per hour.*—Owing to the fact that the incandescent fuel does not rest on the grate, but is supported upon a deep ash bed, the rate of burning is expressed in terms of the area of fuel bed instead of the area of grate, as in boiler practice. This area is the area of a circle whose diameter is the internal diameter of the producer.

The producer used in these tests was 7 feet in internal diameter, thus giving a fuel bed of 38.48 square feet, which for convenience is designated as "A." Item 28=item 22÷A.

Example (test No. 16): $\frac{403.3}{38.48}=10.5$ pounds.

Item 29. *Dry coal consumed per square foot of fuel bed per hour.*—Item 29=item 23÷A.

Example (test No. 16): $\frac{365.3}{38.48}=9.5$ pounds.

Item 30. *Combustible consumed per square foot of fuel bed per hour.*—Item 30=item 24÷A.

Example (test No. 16): $\frac{281.6}{38.48}=7.3$ pounds.

Item 31. *British thermal units per pound of coal as fired.*—This value is taken from the chemist's report. For test No. 16 the value is 9,650 B. T. U.

Item 32. *British thermal units per pound of dry coal.*—This value is taken from the chemist's report. For test No. 16 the value is 10,656 B. T. U.

Item 33. *British thermal units per pound of combustible.*—From item 19, r=per cent of refuse. Item 33=item 32÷(100-r).

Example (test No. 16): $\frac{10,656}{100-22.9}=13,820$ B. T. U.

Item 34. British thermal units from coal as fired per hour.—Item 34=item 31×item 22.

Example (test No. 16): $9,650 \times 403.3 = 3,891,800$ B. T. U.

Item 35. British thermal units from dry coal per hour.—Item 35=item 32×item 23.

Example (test No. 16): $10,656 \times 365.3 = 3,892,600$ B. T. U.

Item 36. British thermal units from combustible per hour.—Item 36=item 33×item 24.

Example (test No. 16): $13,820 \times 281.6 = 3,891,800$ B. T. U.

Item 37. Total gas produced, cubic feet.—(Gas at 62° F. and 14.7 pounds pressure.) The total gas output of the producer consists of the gas passed through the main meter plus that used for the calorimetric determinations. The amount used for the calorimetric work was 10 cubic feet per hour.

The main gas meter was read every twenty minutes through the test, and each twenty-minute reading was separately reduced to the corresponding value for standard gas, i. e., gas at 62° F. and 14.7 pounds pressure.

The temperature of the gas was taken by a thermometer inserted in the main pipe near the entrance to the meter, as shown in Pl. X.

As previously indicated (items 6 and 7, p. 1002), two manometers were also inserted in the main gas pipe, one between the gas holder and meter and the other between the meter and engine. These were designated "Manometer No. 1" and "Manometer No. 2," respectively.

The barometer readings were for a time obtained from the downtown weather bureau in St. Louis, and the necessary corrections for difference in elevation were made. Later the readings were taken at the plant by means of an aneroid barometer, which was frequently calibrated by comparison with the barometer in the United States Government building at the World's Fair grounds.

<i>Data given.</i>	<i>Solution.</i>
v_1 =reading of meter at beginning of twenty-minute interval.	$v_2-v_1=v_g$ =volume of gas during twenty-minute interval.
v_2 =reading at end of twenty-minute interval.	
t_1 =temperature, °F., corresponding to v_1 .	$\frac{t_1+t_2}{2}=t_g$ =average temperature, °F., during twenty-minute interval.
t_2 =temperature, °F., corresponding to v_2 .	
T_g =absolute temperature of gas= t_g+459° .	
p =average barometer reading.	
p_1 =average pressure during entire test as shown by manometer No. 1.	p_m =mean of p_1 and p_2 .
p_2 =do. by manometer No. 2.	$p \times .491$ =pounds per square inch.
p_g =total pressure in pounds per square inch=sum of mean manometer pressure and average barometer pressure in pounds per square inch.	$p_m \times .036$ =pounds per square inch.
T_s =absolute temperature of standard gas= $62^\circ+459^\circ=521^\circ$.	$\frac{v_s}{v_g} = \frac{p_g T_s}{p_s T_g}$
p_s =atmospheric pressure=14.7 pounds per square inch.	$v_s = v_g \frac{p_g T_s}{p_s T_g}$
To find:	
v_s =cubic feet of standard gas.	$v_s = v_g \frac{p_g \times 521}{14.7 \times T_g}$
Example (test No. 16):	
$v_1=8,170,550$.	$v_g=v_2-v_1=5,850$ cubic feet.
$v_2=8,176,400$.	
$t_1=67^\circ$ F.	$t_g = \frac{67+74}{2}=70.5^\circ$ F.
$t_2=74^\circ$ F.	
$T_g=70.5^\circ+459^\circ=529.5^\circ$.	$p_m=1.775$ inches water.
$p=29.42$ inches mercury.	
$p_1=2.43$ inches water.	$29.42 \times .491=14.45$ pounds per square inch.
$p_2=1.12$ inches water.	$1.775 \times .036=.064$ pound per square inch.
$p_g=14.45+0.064=14.514$ pounds per square inch.	$v_s = \frac{5,850 \times 521 \times 14.514}{529.5 \times 14.7} = 5,683$ = cubic feet for twenty minutes.
	Sum of all twenty-minute reductions for entire test=447,400 cubic feet. 300 cubic feet were used by calorimeter, making total of 447,700 cubic feet produced.

Item 38. Gas produced per hour, cubic feet.—Item 38=item 37÷item 1.

Example (test No. 16): $\frac{447,700}{30}=14,923$ cubic feet.

Item 39. Cubic feet of gas per pound coal consumed in producer.—Item 39=item 37÷item 16.

Example (test No. 16): $\frac{447,700}{12,100}=37$ cubic feet.

Item 40. Cubic feet of gas per pound dry coal consumed in producer.—Item 40=item 37÷item 18.

Example (test No. 16): $\frac{447,700}{10,957.8}=40.9$ cubic feet.

Item 41. Cubic feet of gas per pound combustible consumed in producer.—Item 41=item 37÷item 21.

Example (test No. 16): $\frac{447,700}{8,448.5}=53$ cubic feet.

Item 42. Cubic feet of gas per pound equivalent coal used by producer plant.—Item 42=item 38÷item 25.

Example (test No. 16): $\frac{14,923}{459.8}=32.5$ cubic feet.

Item 43. Cubic feet of gas per pound equivalent dry coal used by producer plant.—Item 43=item 38÷item 26.

Example (test No. 16): $\frac{14,923}{416.5}=35.8$ cubic feet.

Item 44. Cubic feet of gas per pound equivalent combustible used by producer plant.—Item 44=item 38÷item 27.

Example (test No. 16): $\frac{14,923}{321.1}=46.5$ cubic feet.

Item 45. British thermal units per cubic foot of standard gas.—The British thermal units from the gas were determined by means of a Junker calorimeter, as described under items 22 and 23 of the log form.

Item 45 is an average of all the values obtained during a test, as given in column 23 of the condensed logs.

For test No. 16 the average value for item 45 was 151 B. T. U.

Item 46. British thermal units from standard gas per pound dry coal burned in producer.—Item 46=item 38×item 45÷item 23.

Example (test No. 16): $\frac{14,923 \times 151}{365.3}=6,168$ B. T. U.

Item 47. British thermal units from standard gas per hour per brake horsepower.—Item 47=item 38×item 45÷item 51.

Example (test No. 16): $\frac{14,923 \times 151}{236.8}=9,516$ B. T. U.

Item 48. Electrical horsepower available for outside purposes.—(See item 49 for method of obtaining E. H. P.) Item 48=item 49—item 12; that is, the “available” horsepower is the switch-board horsepower less that used in operating the machinery of the plant, as explained in item 12 of the report and in item 8, page 1002, of the log.

Example (test No. 16): 201.2—16.4=184.8 electrical horsepower available.

Item 49. Electrical horsepower developed at the switch board.—As indicated in items 12 and 13 of the log (pp. 1018 et seq.) the voltmeter and ammeter were read every twenty minutes during the test. The load on the engine was kept constant by means of the water rheostat described on page 988. One of the chief duties of the switch-board man was to keep the rheostat so adjusted that this much-desired result could be obtained.

Each twenty-minute reading was reduced to its equivalent horsepower by the following familiar rule:

$$\frac{\text{volts} \times \text{amperes}}{746} = \text{horsepower.}$$

For illustration, a single reading only is selected from the log sheet, page 1305, of test No. 16. Take, for example, the reading at 10 a. m. on the first morning of the test:

Volts at 10 a. m. = 240.

Amperes at 10 a. m. = 624.

$$\text{Electrical horsepower} = \frac{240 \times 624}{746} = 200.8.$$

These single values obtained every twenty minutes are averaged for the entire test, this average result being the one reported.

For test No. 16 the average switch-board horsepower was 201.2.

Item 50. Brake horsepower available for outside purposes.—By “available” brake horsepower is meant the brake horsepower developed by the engine less the equivalent brake horsepower necessary for the operation of the auxiliary machinery of the plant.

Owing to the method of installation and the pressure under which the tests were conducted, it was not feasible to determine the brake horsepower of the engine. After some investigation, supplemented by reports from the Westinghouse Company, the efficiency of the generator and belt was assumed as 85 per cent. The brake horsepower used throughout this report is based on this assumption. Item 50 = item 48 ÷ 0.85.

Example (test No. 16): $184.8 \div 0.85 = 217.4$ brake horsepower available.

Item 51. Brake horsepower developed at engine.—Item 51 = item 49 ÷ 0.85.

Example (test No. 16): $201.2 \div 0.85 = 236.8$ brake horsepower at engine.

Item 52. Efficiency of conversion and cleaning gas.—This efficiency is marked to include the cleaning of the gas as distinct from the efficiency of conversion alone, since the heat value of the gas was taken after the gas had passed through the economizer, scrubber, tar extractor, purifier, and holder instead of hot from the producer.

This efficiency is the ratio of the heat units of the gas produced to the heat units of the dry coal charged into the producer. Item 52 = item 38 × item 45 ÷ item 35.

Example (test No. 16): $\frac{14,923 \times 151}{3,892,600} = 58$ per cent.

Item 53. Efficiency of producer plant.—This efficiency is the ratio of the heat units of the gas produced (after cleaning) to the sum of the heat units, equivalent to:

- 1. Dry coal consumed by the producer.
- 2. Steam used for blast.
- 3. Power used to drive auxiliary machinery.

<i>Data given.</i>	<i>Solution.</i>
H=B. T. U. of gas per hour.	H=item 38×item 45.
H'=B. T. U. of dry coal per hour=item 35.	1 H. P.=33,000 foot-pounds per minute.
H''=B. T. U. of dry coal per hour, equivalent to steam used=item 32×item 10.	1 B. T. U.=778 foot-pounds.
H'''=B. T. U. per hour, equivalent to horsepower of auxiliary motors.	B. T. U. per minute for 1 H. P.=42.4.
Example (test No. 16):	Item 53=efficiency= $\frac{H}{H'+H''+H'''}$
Item 38=14,923 cubic feet gas per hour.	H=14,923×151=2,253,370 B. T. U.
Item 45=151.1 B. T. U.	H''=10,656×51.2=545,000 B. T. U.
H'=item 35=3,892,600 B. T. U.	H'''=42.4×16.4×60=41,800 B. T. U.
Item 32=10,656 B. T. U.	H'+H''+H'''=3,892,600+545,000+41,800=
Item 10=51.2 pounds.	4,479,400.
Item 12=16.4=horsepower of auxiliary motors.	Item 53=efficiency of plant= $\frac{2,253,370}{4,479,400}$ =50 per cent.

Items 54-61. Coal per horsepower per hour.—The above heading, “Coal per horsepower per hour,” applies to items 54 to 61, inclusive.

The numerical values are, as in the previous items, from test 16.

	Coal as fired.	Dry coal.	Combustible.
Item 54: Pounds consumed in producer per electrical horsepower available for outside purposes.	= Item 22 = 403.3 = 2.18 lbs. Item 48 184.8	= Item 23 = 365.3 = 1.98 lbs. Item 48 184.8	= Item 24 = 281.6 = 1.52 lbs. Item 48 184.8
Item 55: Pounds consumed in producer per electrical horsepower developed at switch board.	= Item 22 = 403.3 = 2.00 lbs. Item 49 201.2	= Item 23 = 365.3 = 1.82 lbs. Item 49 201.2	= Item 24 = 281.6 = 1.40 lbs. Item 49 201.2
Item 56: Pounds consumed in producer per brake horsepower available for outside purposes.	= Item 22 = 403.3 = 1.86 lbs. Item 50 217.4	= Item 23 = 365.3 = 1.68 lbs. Item 50 217.4	= Item 24 = 281.6 = 1.30 lbs. Item 50 217.4
Item 57: Pounds consumed in producer per brake horsepower developed at engine.	= Item 22 = 403.3 = 1.70 lbs. Item 51 236.8	= Item 23 = 365.3 = 1.54 lbs. Item 51 236.8	= Item 24 = 281.6 = 1.19 lbs. Item 51 236.8
Item 58: Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.	= Item 25 = 459.8 = 2.49 lbs. Item 48 184.8	= Item 26 = 416.5 = 2.25 lbs. Item 48 184.8	= Item 27 = 321.1 = 1.74 lbs. Item 48 184.8
Item 59: Equivalent pounds used by producer plant per electrical horsepower developed at switch board.	= Item 25 = 459.8 = 2.28 lbs. Item 49 201.2	= Item 26 = 416.5 = 2.07 lbs. Item 49 201.2	= Item 27 = 321.1 = 1.60 lbs. Item 49 201.2
Item 60: Equivalent pounds used by producer plant per brake horsepower available for outside purposes.	= Item 25 = 459.8 = 2.11 lbs. Item 50 217.4	= Item 26 = 416.5 = 1.92 lbs. Item 50 217.4	= Item 27 = 321.1 = 1.48 lbs. Item 50 217.4
Item 61: Equivalent pounds used by producer plant per brake horsepower developed at engine.	= Item 25 = 459.8 = 1.94 lbs. Item 51 236.8	= Item 26 = 416.5 = 1.76 lbs. Item 51 236.8	= Item 27 = 321.1 = 1.36 lbs. Item 51 236.8

Item 62. Average composition of coal.—These results are taken from the chemist's report. (For full information see report of Prof. N. W. Lord, p. 174.) For test No. 16 the following are the results:

	Per cent.
Moisture	9.44
Volatile matter	35.02
Fixed carbon	34.82
Ash.....	20.72
	100.00
Sulphur	3.91

Item 63. Average composition of gas.—These values are an average of all the gas analyses made during the test. (For methods of analysis employed see p. 1004.) The average of the fifteen gas analyses made during test No. 16 is as follows:

	Per cent.
Carbon dioxide (CO ₂)	10.21
Oxygen (O ₂).....	.59
Carbon monoxide (CO)	15.46
Hydrogen (H ₂)	10.79
Methane (CH ₄).....	5.52
Nitrogen (N ₂).....	57.43
	100.00

Owing to the fact that these tests have been primarily conducted as fuel tests, or producer-gas tests, and not as gas-engine tests, a complete detailed report of the performance of the gas engine has not been attempted. In submitting the general report it has, however, seemed proper to present brief records of the gas-engine operations, together with typical indicator cards from each test.

The following pages will, therefore, contain the results of the producer-gas investigations in the following order:

1. Condensed tabulated log sheets.
2. Graphic log sheet.
3. Detailed report of producer-gas tests.
4. Brief record of gas-engine performance, showing typical cards.

RESULTS OF TESTS.

ALABAMA No. 2.

GENERAL RESULTS.

Alabama No. 2 is a clean, hard coal, which was fed in 1 to 1½ inch lumps, and worked well in the producer. It did not cake excessively and was easily handled. The greatest trouble in its use arose from its tendency to shrink away from the walls of the producer. It was necessary, therefore, to break it against the walls about twice every hour. The lumps did not swell and fuse together, but seemed to keep apart in the fire.

Log of producer-gas test No. 2, Alabama No. 2 coal, October 10-14, 1904.
[Coal from mine No. 5 of the Galloway Coal Company, Carbon Hill, Ala.]

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer.		Manometers at producer.		Temperatures (° C.).				Gas calorimeter.		B. T. U.
		1.	2.	1.	2.	1.	2.	1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amps.	14	15	16	17	18	19	20	21	22	23	
1																										
12 m. ^a		1,082,850	77.0	24,780 ^b	2.4	1.1						42,329	529	240	630											(b)
12.20 p. m.		1,089,150	78.5		2.3	1.0						44,539	2,539	239	635											
12.40 p. m.		1,095,700	79.0		2.3	.8						46,543	4,543	241	619											
12.45 p. m.	300																									
1 p. m.		1,102,400	79.0		2.3	.8						48,548	6,548	241	619											
1.20 p. m.		1,108,750	79.5		2.3	.8						50,556	8,556	241	619											
1.30 p. m.	300																									
1.40 p. m.		1,114,750	80.0		2.3	1.0						52,566	10,566	240	614											
2 p. m.		1,120,725	80.5	25,025	2.3	1.0						54,578	12,578	241	619											
2.20 p. m.		1,126,810	80.5		2.3	1.0						56,585	14,585	241	619											
2.30 p. m.	300																									
2.40 p. m.		1,132,950	81.0		2.3	1.0						58,596	(c)	241	610											
3 p. m.		1,139,275	81.5		2.3	.8						60,601	(c)	241	620											
3.15 p. m.	300																									
3.20 p. m.		1,145,710	82.0		2.2	.8						62,608		241	620											
3.40 p. m.		1,151,940	82.0		2.2	1.0						64,613	18,613	241	620											
4 p. m.		1,157,975	82.5	25,349	2.3	1.0						66,627	20,627	241	610											
4.15 p. m.	200																									
4.20 p. m.		1,164,150	82.0		2.3	1.0						68,640	22,640	241	620											
4.40 p. m.		1,170,200	81.5		2.3	1.0						70,650	24,650	241	620											
4.45 p. m.	300																									
5 p. m.		1,176,280	81.0	25,510	2.3	1.0						72,657	26,657	241	620											

^a October 10. Barometer 29.36 inches.
^b Gas meter connected to calorimeter out of order; B. T. U. calculated from gas analyses. (See analyses, pp. 1025.)
^c Speed counter out of order.

Log of producer-gas test No. 2, Alabama No. 2 coal, October 10-14, 1904—Continued.

Time.	Coal consumed by producer (pounds).	(Gas meter (cubic feet).	Temperature of gas (° F.).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer.		Manometers at producer.		Gas calorimeter.						B. T. U.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
				1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	14	15	Air entering (inches mer- cury).	Gas leaving (inches wa- ter).	Gas.	Temperatures (° C.).		Cubic centimeters of water collected.	Cubic feet of gas.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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^a October-11. Barometer 29.55 inches.

Log of producer-gas test No. 2, Alabama No. 2 coal, October 10-14, 1904—Continued.

Time.		Coal consumed by producer (pounds).	Temperature of gas (° F.).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Gas calorimeter.						B. T. U.					
											Load.		Temperature of gas leaving producer.		Manometers at producer.			Temperatures (° C.).				Cubic feet of gas.
																		Volts.	Amperes.	Gas.	Inlet.		Outlet.	Cubic centimeters of water collected.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
1.50 p. m.		1,301,250	78.0		2.3	1.1			13,798	67,798	242	615			3.7							
2.10 p. m.		1,307,700	78.0		2.3	.8			15,809	69,809	242	620			6.0							
2.15 p. m.	300																					
2.30 p. m.		1,314,210	78.0		2.3	.8			17,818	71,818	242	615			6.0							
2.50 p. m.		1,320,660	78.0		2.3	.8			19,827	73,827	242	620			5.5							
3.10 p. m.		1,327,250	78.0		2.3	.6			21,837	75,837	241	630			6.5							
3.15 p. m.	300																					
3.30 p. m.		1,333,670	78.0	26,897	2.3	.9			23,850	77,850	241	620			6.0							
3.50 p. m. ^a		1,339,900	78.0		2.3	1.0			25,866	79,866	242	620										
7.30 a. m. ^b	150	1,344,380	64.0	27,590	2.3	1.1			27,286	81,286	242	656			3.7							
7.50 a. m.		1,350,050	66.5		2.4	1.2			29,299	83,299	241	640			5.0							
8.10 a. m.		1,355,660	68.5		2.4	1.5			31,308	85,308	241	625			4.2							
8.30 a. m.	300	1,360,660	70.0		2.4	1.5			33,317	87,317	241	620			4.3							
8.50 a. m.		1,365,840	71.5		2.4	1.4			35,322	89,322	240	630			4.4							
9.10 a. m.		1,370,990	72.0		2.4	1.4			37,329	91,329	241	625			4.3							
9.30 a. m.		1,376,440	72.5	27,635	2.4	1.3			39,336	93,336	241	620			4.0							
9.45 a. m.	300																					
9.50 a. m.		1,382,140	73.0		2.4	1.1			41,338	95,338	240	625			4.8							
10.10 a. m.		1,388,050	73.5		2.4	1.1			43,344	97,344	241	625			4.5							
10.30 a. m.		1,393,950	74.0		2.4	1.1			45,349	99,349	241	620			4.0							
10.45 a. m.	300																					
10.50 a. m.		1,399,840	74.0		2.4	1.1			47,352	1,352	241	610			4.6							
11.10 a. m.		1,405,680	75.0		2.4	1.1			49,357	3,357	241	620			4.3							
11.30 a. m.		1,411,490	75.5	27,845	2.4	1.1			51,362	5,362	241	620			4.5							
11.45 a. m.	300																					

^a At 3.55 p. m. the left igniter trip buffer nuts slacked off, grounding the igniter circuit and bringing the test to a sudden close.

^b October 12. Barometer 29.67 inches.

Log of producer-gas test No. 2, Alabama No. 2 coal, October 10-14, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.	Load.		Temperature of gas leaving producer.	Manometers at pro- ducer.		Temperatures (° C.).				Gas calorimeter.		B. T. U.	
					1.	2.	Watt meter.	Ammeter.		1.	2.		Volts.	Amperes.	Air entering (inches mer- cury).	Gas leaving (inches wa- ter).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.		Cubic feet of gas.
1		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
11.50 a. m.		1,417,340	76.0		2.4	1.1			53,368	7,368	241	620			4.6							
12.10 p. m.		1,423,310	76.0		2.4	1.1			55,262	7,662	241	615			3.9							
12.30 p. m.		1,429,340	76.0	28,060	2.4	1.0			57,264	9,664	241	620			6.0							
12.50 p. m.		1,435,210	76.0		2.4	1.1			59,273	11,673	238	610			5.2							
1 p. m.	300																					
1.10 p. m.		1,441,080	75.5		2.4	1.1			61,284	13,684	242	620			4.5							
1.30 p. m.		1,446,920	76.0	28,060	2.4	1.1			63,294	15,694	242	615			4.8							
1.50 p. m.		1,452,770	76.5		2.4	1.1			65,307	17,707	242	615			5.1							
2.05 p. m.	300																					
2.10 p. m.		1,458,690	77.0		2.4	1.0			67,320	19,720	243	615			5.6							
2.30 p. m.		1,464,650	76.5		2.4	1.0			69,330	21,730	141	620			5.3							
2.50 p. m.		1,470,630	77.0		2.4	1.0			71,340	23,740	241	615			5.2							
3 p. m.	300																					
3.10 p. m.		1,477,040	77.5		2.3	.8			73,350	25,750	242	620			5.0							
3.30 p. m.		1,483,390	77.5	28,330	2.3	1.0			75,360	27,760	242	620			6.5							
3.45 p. m.	300																					
3.50 p. m.		1,489,240	78.0		2.3	1.0			77,368	29,768	242	615			5.8							
4.10 p. m.		1,495,070	77.0		2.3	1.1			79,376	31,776	242	610			5.7							
4.30 p. m.		1,500,880	75.0		2.3	1.1			81,382	33,782	241	620			5.7							
4.45 p. m.	300																					
4.50 p. m.		1,506,850	74.5		2.4	1.1			83,390	35,790	243	620			5.4							
5.10 p. m.		1,512,810	74.0		2.4	1.0			85,398	37,798	241	620			4.8							
5.30 p. m.		1,518,820	73.0	28,690	2.4	.9			87,404	39,804	242	605			4.5							
7.30 a. m. ^b	200	1,521,200	62.0	29,046	2.2	.9			88,181	40,581	241	619			6.0							
7.50 a. m.		1,527,500	65.0		2.4	1.2			90,198	42,598	242	619			6.8							

^a Both speed counters out of order. Count by hand counter showed 200 r. p. m.

^b October 13. Barometer 29.83 inches.

Log of producer-gas test No. 2, Alabama No. 2 coal, October 10-14, 1904—Continued.

Time.	(Coal consumed by producer (pounds).)	(Gas meter (cubic feet).)	Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motor.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer.		Manometers at producer.		Gas calorimeter.				B. T. U.
				1.	2.	1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amps.	14	15	16	17	18	19	20	21	22
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2.45 p. m.	300	1,653,000	74.0		2.3	0.8				32,468	84,868	241	614			6.5						
2.50 p. m.		1,659,300	74.0		2.3	.8				34,482	86,882	242	619			1.5						
3.10 p. m.		1,665,500	74.5	30,270	2.3	.9				36,493	88,883	241	619			6.5						
3.30 p. m.																						
3.45 p. m.	300	1,671,800	74.5		2.3	.9				38,503	90,903	241	619			6.0						
3.50 p. m.		1,677,975	74.5		2.3	1.0				40,513	92,913	242	619			3.0						
4.10 p. m.		1,684,110	73.5		2.3	.9				42,522	94,922	241	619			3.0						
4.30 p. m.																						
4.45 p. m.	300	1,690,300	72.5		2.3	.9				44,530	96,930	242	624			6.0						
4.50 p. m.		1,696,300	72.5		2.3	1.0				46,542	98,942	241	619			6.0						
5.10 p. m.		1,702,200	72.0	30,605	2.3	.9				48,554	00,954	241	619									
5.30 p. m.		1,704,410	62.0	30,710	2.3	.9				49,366		241	619			5.0						
7.30 a. m.	200	1,710,310	63.5		2.3	1.1				51,384		242	630			5.0						
7.50 a. m.																						
8 a. m.	300	1,715,900	65.0		2.3	1.1				53,404		241	624			5.0						
8.10 a. m.		1,721,250	66.0		2.4	1.2				55,421	01,421	241	630			5.0						
8.30 a. m.		1,726,750	66.5		2.3	1.1				57,440	3,440	241	624			4.0						
8.50 a. m.																						
9 a. m.	300	1,732,330	67.5		2.3	1.1				59,450	5,450	241	619			5.0						
9.10 a. m.		1,738,180	68.5	30,975	2.3	1.1				61,461	7,461	242	624			5.0						
9.30 a. m.		1,744,000	69.5		2.3	1.0				63,474	9,474	241	624			3.0						
9.50 a. m.																						
10 a. m.	300	1,749,900	70.0		2.3	1.0				65,485	11,485	24	624			5.0						
10.10 a. m.		1,755,600	71.0		2.3	1.1				67,497	13,497	241	619			5.5						
10.30 a. m.										69,510	15,510	241	624			3.0						
10.50 a. m.		1,761,250	71.5		2.3	1.1																

"October 14. Circuit breaker thrown out for about a minute.

Year	Month	Day	Time	Location	Remarks
1900	Jan	1	10:00	San Francisco	Arrived from New York
1900	Jan	2	10:00	San Francisco	Left for New York
1900	Jan	3	10:00	San Francisco	Arrived from New York
1900	Jan	4	10:00	San Francisco	Left for New York
1900	Jan	5	10:00	San Francisco	Arrived from New York
1900	Jan	6	10:00	San Francisco	Left for New York
1900	Jan	7	10:00	San Francisco	Arrived from New York
1900	Jan	8	10:00	San Francisco	Left for New York
1900	Jan	9	10:00	San Francisco	Arrived from New York
1900	Jan	10	10:00	San Francisco	Left for New York
1900	Jan	11	10:00	San Francisco	Arrived from New York
1900	Jan	12	10:00	San Francisco	Left for New York
1900	Jan	13	10:00	San Francisco	Arrived from New York
1900	Jan	14	10:00	San Francisco	Left for New York
1900	Jan	15	10:00	San Francisco	Arrived from New York
1900	Jan	16	10:00	San Francisco	Left for New York
1900	Jan	17	10:00	San Francisco	Arrived from New York
1900	Jan	18	10:00	San Francisco	Left for New York
1900	Jan	19	10:00	San Francisco	Arrived from New York
1900	Jan	20	10:00	San Francisco	Left for New York
1900	Jan	21	10:00	San Francisco	Arrived from New York
1900	Jan	22	10:00	San Francisco	Left for New York
1900	Jan	23	10:00	San Francisco	Arrived from New York
1900	Jan	24	10:00	San Francisco	Left for New York
1900	Jan	25	10:00	San Francisco	Arrived from New York
1900	Jan	26	10:00	San Francisco	Left for New York
1900	Jan	27	10:00	San Francisco	Arrived from New York
1900	Jan	28	10:00	San Francisco	Left for New York
1900	Jan	29	10:00	San Francisco	Arrived from New York
1900	Jan	30	10:00	San Francisco	Left for New York
1900	Jan	31	10:00	San Francisco	Arrived from New York

PRODUCER-GAS TESTS.

1025

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.	B. T. U. standard- ized.
12.20 p. m. ^a	7.4	0.0	16.8	5.5	6.1	64.2	100.0	142.7	150.7
1.20 p. m.	10.0	.0	12.4	3.1	6.3	68.2	100.0	120.2	137.4
2.20 p. m.	10.2	.0	11.4	4.6	6.1	67.7	100.0	120.7	127.5
3.20 p. m.	9.4	.0	16.0	6.5	4.6	63.5	100.0	127.5	134.6
4.20 p. m.	8.8	.2	16.4	13.1	5.0	56.5	100.0	156.1	164.9
8.20 a. m. ^b	6.0	.2	21.4	7.9	3.9	60.6	100.0	143.7	151.0
9 a. m.	7.6	.2	18.8	9.9	3.5	60.0	100.0	137.0	143.9
10 a. m.	7.2	.0	19.8	5.3	3.6	64.1	100.0	125.9	132.2
11 a. m.	7.4	.0	18.0	6.3	4.8	63.5	100.0	135.9	142.8
12 m.	8.2	.2	16.2	7.2	3.9	64.3	100.0	123.1	129.4
1 p. m.	8.6	.2	16.4	9.3	4.4	61.1	100.0	136.4	143.2
2 p. m.	9.0	.0	16.1	5.3	5.9	63.7	100.0	138.5	145.6
3 p. m.	8.8	.2	16.0	6.0	6.6	62.4	100.0	147.0	154.4
3.55 p. m. ^c	8.4	.2	17.0	7.1	7.1	60.2	100.0	159.6	167.6
7.55 a. m. ^d	6.4	.0	20.6	10.3	4.8	57.9	100.0	158.9	165.6
8.10 a. m.	4.4	.0	24.6	4.3	3.5	63.2	100.0	138.1	144.0
9.40 a. m.	7.0	.2	17.2	4.1	6.5	65.0	100.0	143.5	149.7
10.25 a. m.	7.4	.0	16.6	6.9	6.6	62.5	100.0	152.0	158.5
11.10 a. m.	7.8	.0	15.2	8.6	5.9	62.5	100.0	145.0	151.2
12.05 p. m.	7.6	.4	15.0	4.7	8.2	64.1	100.0	166.0	173.1
1.05 p. m.	7.7	.3	14.8	4.5	6.0	66.7	100.0	137.2	143.1
2 p. m.	7.8	.2	14.8	4.0	7.9	65.3	100.0	149.8	156.2
5 p. m.	9.0	.0	12.0	7.3	6.1	65.6	100.0	132.2	137.8
4.15 p. m.	9.2	.2	13.4	6.7	9.3	61.2	100.0	161.9	168.8
8.10 a. m. ^e	3.7	.0	23.9	11.4	4.8	56.2	100.0	174.2	179.0
9 a. m.	5.8	.0	18.2	8.3	7.7	60.0	100.0	174.4	179.2
9.50 a. m.	7.4	.0	16.7	1.2	5.6	69.1	100.0	122.0	125.4
10.45 a. m.	8.7	.3	12.8	7.9	4.4	65.9	100.0	119.0	122.3
11.40 a. m.	9.0	.0	11.8	11.0	5.6	62.6	100.0	139.0	142.9
12.30 p. m.	9.4	.0	12.0	5.0	6.2	67.4	100.0	125.3	128.8
1.30 p. m.	9.4	.0	12.2	12.6	7.8	58.0	100.0	169.2	173.8
2.30 p. m.	8.6	.0	13.1	5.8	9.7	62.8	100.0	141.3	145.2
3.30 p. m.	9.6	.2	13.0	6.1	9.3	61.8	100.0	166.6	171.3
4.30 p. m.	10.0	.0	12.0	2.1	9.4	66.5	100.0	149.3	153.4
8.10 a. m. ^f	5.2	.2	23.0	10.1	5.9	55.6	100.0	178.3	182.5
9 a. m.	7.8	.0	22.0	8.9	1.6	59.7	100.0	140.0	143.3
10 a. m.	7.8	.0	20.4	9.5	3.4	58.9	100.0	153.7	157.4
10.50 a. m.	8.2	.1	19.1	13.3	3.5	55.8	100.0	150.0	153.5
11.40 a. m.	8.4	.2	17.0	8.5	6.0	59.9	100.0	153.0	156.6
12.45 p. m.	9.6	.0	13.9	3.7	8.0	64.8	100.0	147.5	151.0
1.35 p. m.	9.8	.2	19.2	8.0	3.6	59.2	100.0	133.3	136.4
2.30 p. m.	10.0	.0	19.4	7.0	2.8	60.8	100.0	121.9	124.8
3.40 p. m.	9.2	.4	18.4	8.1	4.1	59.8	100.0	136.1	139.3
4.30 p. m.	10.0	.2	18.0	9.8	2.3	59.7	100.0	121.5	124.4

^a October 10.
^b October 11.

^c Gas sample taken from cock back of gas engine.
^d October 12.

^e October 13.
^f October 14.

Producer-gas test No. 2, Alabama No. 2 coal.

[Recorded by M. H. Mount and R. E. Peshak, October 10-14, 1904.]

1. Duration of test, in hours	43
AVERAGE TEMPERATURE, ° F.	
2. Gas leaving producer	
3. Gas leaving economizer ^a	
4. Gas entering holder	
5. Air entering economizer	
6. Air leaving economizer	
OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
7. Total steam used by producer	9,200 pounds..
8. Steam used by producer per hour	214 do..
9. Equivalent in pounds of coal per hour	30.9
10. Equivalent in pounds of dry coal per hour	29.7
11. Equivalent in pounds of combustible per hour	26.8
12. Average horsepower required to drive auxiliary machinery	8
13. Total water used in scrubber and tar extractor	5,979 cubic feet..
14. Cubic feet of water per hour per horsepower of producer plant	.56
15. Cubic feet of water per 1,000 cubic feet of gas produced	7.72
COAL CONSUMED IN PRODUCER.	
16. Total coal consumed	13,350 pounds..
17. Moisture in coal	3.76 per cent..
18. Total dry coal consumed	12,848 pounds..
19. Refuse from dry coal	9.85 per cent..
20. Total refuse from coal	1,350 pounds..
21. Total combustible consumed	12,035 do..
COAL PER HOUR.	
22. Coal consumed in producer	310.5 pounds..
23. Dry coal consumed in producer	299 do..
24. Combustible consumed in producer	280 do..
25. Equivalent coal used by producer plant	341.4 do..
26. Equivalent dry coal used by producer plant	328.7 do..
27. Equivalent combustible used by producer plant	306.8 do..
FUEL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.	
28. Coal as fired	8.07
29. Dry coal	7.78
30. Combustible	7.28

^a By special request of R. D. Wood & Co., the manufacturers of the gas producer, the temperatures indicated by items 3, 4, 5, and 6 were not taken during these preliminary tests.

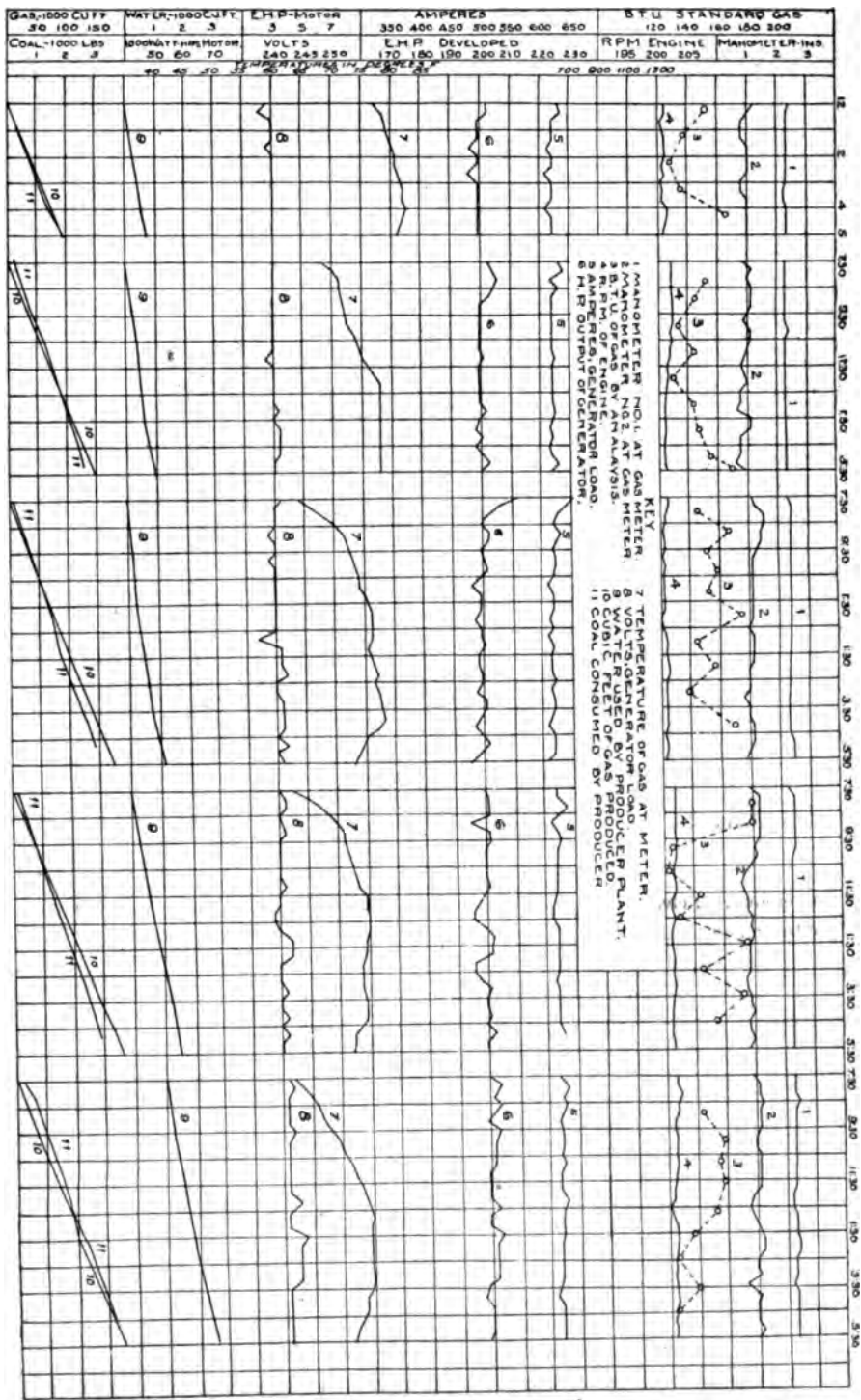


Fig. 111.—Graphic log sheet, producer-gas test, Alabama No. 2 coal.

OPERATIONS OF THE COAL-TESTING PLANT.

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired	12,865
32. Per pound of dry coal	13,365
33. Per pound of combustible	14,820
34. From coal as fired, per hour	4,000,000
35. From dry coal, per hour	4,000,000
36. From combustible, per hour	4,000,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total	775,500
38. Per hour	18,050
39. Per pound coal consumed in producer	58.1
40. Per pound dry coal consumed in producer	60.4
41. Per pound combustible consumed in producer	64.5
42. Per pound equivalent coal used by producer plant	52.9
43. Per pound equivalent dry coal used by producer plant	55.0
44. Per pound equivalent combustible used by producer plant	58.9

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot	149.2
46. Per pound dry coal burned in producer	9,000
47. Per hour per brake horsepower	11,420

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes	192.6
49. Electrical horsepower developed at switch board	200.6
50. Brake horsepower available for outside purposes	226.6
51. Brake horsepower developed at engine	235.5

EFFICIENCIES.

52. Of conversion and cleaning gas	.674
53. Of producer plant	.61

PRODUCER-GAS TESTS.

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COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes	1.61	1.55	1.45
55. Pounds consumed in producer per electrical horsepower developed at switch board	1.55	1.49	1.40
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes	1.37	1.32	1.23
57. Pounds consumed in producer per brake horsepower ^a developed at engine	1.32	1.27	1.19
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	1.77	1.71	1.59
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board	1.71	1.64	1.53
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes	1.51	1.45	1.35
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine	1.45	1.40	1.30

^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture	3.76	Carbon dioxide (CO ₂)	8.16
Volatile matter	33.45	Oxygen (O ₂)	.10
Fixed carbon	53.29	Carbon monoxide (CO)	16.65
Ash	9.50	Hydrogen (H ₂)	7.20
	100.00	Methane (CH ₄)	5.64
Sulphur	.86	Nitrogen (N ₂)	62.25
			100.00

GAS ENGINE.

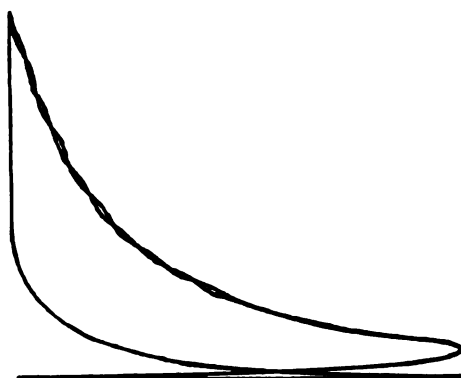
Gas-engine test No. 2 was divided into sections as follows:

	Hours.
October 10, 12 m. to 5 p. m.	5
October 11, 7.30 a. m. to 3.30 p. m.	8
October 12, 7.30 a. m. to 5.30 p. m.	10
October 13, 7.30 a. m. to 5.30 p. m.	10
October 14, 7.30 a. m. to 5.30 p. m.	10
	43

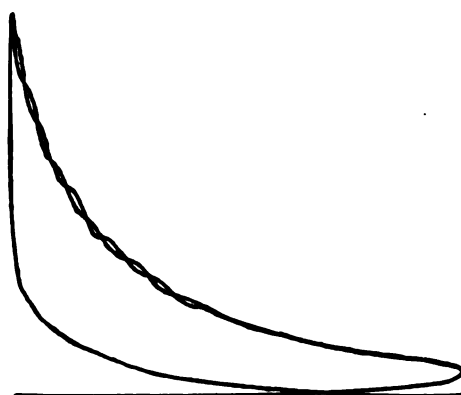
Item 12, the average horsepower required to drive auxiliary machinery, was not determined during this test. The value used, viz, 8 horsepower, was obtained from later tests and substituted in test No. 2.

At the beginning of test No. 2 the 240-pound spring used in the indicators was replaced by a 160-pound spring. The latter was used throughout the remaining tests.

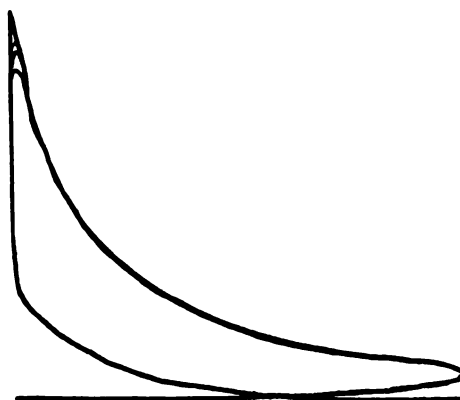
The waves that appear frequently in the expansion curve are due in part to a slight vibration of the indicator rigging. The motion of the indicators is controlled by three eccentrics mounted on the end of the crank shaft. The action of these eccentrics is transmitted to the indicators by wooden rods. These connections are long and there is considerable vibration to the parts. It is probable that the cards taken are not quite true. The indicated horsepower calculated



Right cylinder. M. E. P., ^a 66; Max., ^b 306; Rel., ^c 29; I. H. P., ^d 104.9.



Center cylinder. M. E. P., 62; Max., 300; Rel., 32; I. H. P., 99.3.



Left cylinder. M. E. P., 60; Max., 300; Rel., 28; I. H. P., 95.4.

Indicator diagrams taken October 13, 1904, during gas-engine test No. 2, on Alabama No. 2 coal. Scale of spring, 80; revolutions per minute, 201.8.

from them may be slightly exaggerated, but the cards serve to show the time of ignition, the progress of combustion, and the various valve functions, and in this way they are of great assistance in the proper manipulation of the engine.

During the first two tests considerable tar crept through to the engine, causing some annoyance in the operation of the engine valves. This passing of tar beyond the tar extractor was due to two causes: (1) The tar extractor was hardly

^a Mean effective pressure.

^b Maximum pressure.

^c Pressure at release.

^d Indicated horsepower.

large enough; (2) the speed of the tar extractor fluctuated greatly, at times being far below that required. Before beginning test No. 3 a larger and more modern tar extractor was installed and the results from this have been highly satisfactory.

Report of gas-engine test No. 2.

Recorded by R. W. Cummings and W. C. Weidmann, October 10-14, 1904.

Producer test No. 2.

Coal: General number, Alabama No. 2; special number, G. P. 2. Car initials and number, St. L. and S. F. 16260.

Duration of test, in hours.....	43
Revolutions per minute (mean).....	201.1
Explosions per minute (mean).....	100.5
Cubic feet gas per hour, by meter.....	17,980
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	17,480
Maximum pressure:	
First cylinder.....	282.9
Second cylinder.....	286.5
Third cylinder.....	279
Pressure at release:	
First cylinder.....	30.3
Second cylinder.....	31
Third cylinder.....	28.8
Mean effective pressure:	
First cylinder.....	64.45
Second cylinder.....	63.2
Third cylinder.....	57.4
Indicated horsepower:	
First cylinder.....	102.07
Second cylinder.....	100.01
Third cylinder.....	91.29
Total indicated horsepower.....	293.37
Horsepower delivered (electrical horsepower).....	200.6
Mechanical efficiency (engine and generator combined)..... per cent..	68.2
Cubic feet standard gas per hour per indicated horsepower.....	59.6
Cubic feet standard gas per hour per electrical horsepower.....	87.4

COLORADO No. 1.

GENERAL RESULTS.

Colorado No. 1 is a black lignite which clinkered badly in the producer, in spite of frequent poking, but the clinkers were not large and could be broken from the top of the producer. The gas was of a good, uniform quality, and there is no doubt that the fuel can be used to advantage in producers. It yielded 60 gallons of yellow "lignite tar."

Log of producer-gas test No. 15, Colorado No. 1 coal, December 13, 14, 1904.
[Black lignite from Simpson mine of the Northern Coal and Coke Company, Lafayette, Colo.]

Time.	(Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Temperatures (° C.).			Gas calorimeter.		B. T. U.
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	Air entering producer (° C.).	Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
10 a. m.	300	7,706,290	36.0	(a)	2.5	0.9	611,940		41,188		240	624		0.5	5.0							
10.20 a. m.		7,711,500	39.0		2.5	1.2			43,220	00,000	240	624	300									
10.40 a. m.		7,716,220	42.0		2.8	1.6				2,031	240	614		.5	5.0	9.8	5.8	14.38	1,250	0.3	141.7	138.3
10.45 a. m.	300																					
11 a. m.		7,720,900	43.0		2.8	1.5	614,030			4,056	240	624				9.9	5.9	14.50	1,250	.3	142.1	138.8
11.20 a. m.		7,725,520	45.0		2.6	1.4				6,079	238	639		.5	5.0	10.0	5.9	14.60	1,260	.3	141.8	141.5
11.30 a. m.	300																					
11.40 a. m.		7,730,100	47.0		2.7	1.5				8,111	241	619				10.8	5.8	14.95	1,220	.3	147.6	144.5
12 m.		7,734,500	48.0		2.7	1.6	616,250			10,139	238	624				10.2	5.8	14.70	1,260	.3	148.0	144.7
12.15 p. m.	300																					
12.30 p. m.		7,739,050	48.0		2.6	1.5				12,165	241	634				10.3	5.8	14.55	1,280	.3	148.0	144.8
12.40 p. m.		7,743,550	49.0		2.6	1.5			57,413	14,191	240	624		.5	5.0	10.4	6.1	14.90	1,290	.3	150.0	146.8
1 p. m.		7,748,200	49.0		2.6	1.5	618,520			16,221	240	624	350	.4	5.0							
1.15 p. m.	300																					
1.20 p. m.		7,752,940	49.0		2.6	1.5				18,245	241	624	300									
1.40 p. m.		7,757,610	50.0		2.7	1.6			20,271	240	629	370				12.5	6.1	14.00	1,350	.3	140.9	138.7
2 p. m.		7,762,450	50.0		2.7	1.4	621,110			22,289	240	624	370			12.5	6.2	16.60	950	.3	130.5	128.5
2.15 p. m.	300																					
2.20 p. m.		7,767,500	51.0		2.7	1.4				24,315	242	609	330	.4	5.0	12.5	6.0	18.60	1,180	.4	147.2	144.9
2.40 p. m.		7,772,310	51.0		2.7	1.5			26,351	241	624	330				12.0	6.0	18.80	870	.3	147.2	144.8
3 p. m.		7,777,150	51.0		2.6	1.4	623,310		71,623	28,389	240	624	370			12.0	6.0	18.10	1,170	.4	140.1	137.8
3.15 p. m.	300																					
3.20 p. m.		7,782,100	52.0		2.6	1.4				30,420	240	629	260	.6	6.0	12.0	6.1	15.30	1,130	.3	137.3	135.0

^a Water meter out of order.

Average barometer for entire test, 29.89 inches.

PRODUCER-GAS TESTS.

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Log of producer-gas test No. 15, Colorado No. 1 coal, December 13, 14, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manome- ters at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manome- ters at pro- ducer.		Gas calorimeter.					B. T. U.			
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	13	14	15	16	17	18	19	20	21	22	23		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23			
3.40 p. m.		7,796,890	52.0		2.6	1.4				32,457	240	624	320				12.5	6.0	15.20	1,580	0.4	139.2			137.0
4 p. m.	300	7,791,780	52.0		2.6	1.4	625,760			34,493	240	624					12.5	6.0	15.00	760	.2	135.7			133.6
4.20 p. m. a.		7,796,780	52.5		2.6	1.4				36,512	240	624					12.5	5.9	14.70	800	.2	139.6			137.4
4.40 p. m.	300																								
5 p. m.		7,803,320	52.5		2.6	1.2	627,530			38,764	241	624	260	0.7	6.0	12.5	5.9	13.70	1,470	.8	151.6				149.3
5.20 p. m.		7,808,300	52.5		2.6	1.2				40,791	240	634	300			12.5	6.0	13.60	1,000	.2	150.8				148.5
5.40 p. m.		7,813,200	53.0		2.6	1.2				42,819	240	619	320			12.5	6.0	13.35	1,040	.2	151.6				149.3
5.45 p. m.	300																								
6 p. m.		7,818,280	54.0		2.6	1.2	630,400			44,838	241	629	310	.5	4.5	12.5	6.15	13.70	1,010	.2	151.2				148.8
6.20 p. m.		7,823,120	54.0		2.6	1.2				46,870	242	639	320			12.5	6.1	13.75	1,060	.2	161.1				158.6
6.30 p. m.	300																								
6.40 p. m.		7,827,870	54.0		2.6	1.3				48,888	242	624	260	.5	4.5	12.0	6.0	13.80	1,020	.2	157.5				154.9
7 p. m.		7,832,210	54.0		2.6	1.3	633,240			50,904	241	604	310			12.0	5.9	13.90	1,000	.2	158.7				156.1
7.15 p. m.	300																								
7.20 p. m.		7,836,750	54.0		2.5	1.2			96,322	52,924	240	624	340	.5	5.0										
7.40 p. m.		7,841,500	54.5		2.5	1.2				54,943	240	614	300			12.0	6.0	13.60	1,010	.2	152.0				149.5
8 p. m.	300	7,846,500	54.5		2.5	1.1	635,790			56,948	239	614	350			12.0	6.0	13.10	1,050	.2	147.6				145.2
8.20 p. m.		7,851,600	55.0		2.5	1.1				58,949	242	624	310			12.5	6.1	13.4	1,020	.2	146.6				144.3
8.40 p. m.		7,856,650	55.0		2.5	1.1				60,957	240	634	320	.45	4.5	12.5	6.1	13.7	1,030	.2	155.1				152.7
8.45 p. m.	300																								
9.00 p. m.		7,861,500	55.0		2.5	1.1	638,500			62,974	240	634	340			12.5	6.1	13.8	1,000	.2	152.8				150.4
9.20 p. m.		7,866,490	55.0		2.5	1.1				64,986	239	629	340			12.5	6.0	13.6	1,010	.2	152.0				149.7
9.30 p. m.	300																								
9.40 p. m.		7,871,600	55.5		2.5	1.2				66,992	240	624	340			12.5	6.0	13.8	1,010	.2	156.0				153.6
10 p. m.		7,876,580	56.0		2.5	1.1	641,140			69,000	238	629	380	.6	5.5	13.0	6.2	13.1	1,150	.2	157.1				154.9

^a From 4.25 p. m. to 4.45 p. m. the engine was shut down to change the indicator cocks, which leaked badly and caused back firing.

Log of producer-gas test No. 2, Alabama No. 2 coal, October 10-14, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (°F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer.		Manometers at producer.		Gas calorimeter.					B. T. U.	
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	
11 a. m. a.	300																						
11.10 a. m.		1,766,900	72.0		2.3	1.1																	
11.30 a. m.		1,772,610	73.0	31,245	2.3	1.1			73,530	19,530	241	619			5.25								
11.50 a. m.		1,778,570	73.5		2.3	1.1			75,536	21,536	241	619			6.0								
12 m.	300																						
12.10 p. m.		1,784,840	74.0		2.2	.9			77,542	23,542	243	630			7.0								
12.30 p. m.		1,791,290	74.5		2.2	.8			79,544	25,544	243	624			7.75								
12.50 p. m.		1,797,550	75.0		2.3	.9			81,552	27,552	241	619			5.75								
1 p. m.	300																						
1.10 p. m.		1,803,690	74.5		2.3	1.0			83,565	29,565	241	619			6.0								
1.30 p. m.		1,809,650	74.5	31,572	2.3	1.1			85,577	31,577	244	624			6.5								
1.45 p. m.	300																						
1.50 p. m.		1,815,420	74.5		2.4	1.2			87,590	33,590	243	619			5.5								
2.10 p. m.		1,821,110	74.5		2.4	1.2			89,601	35,601	243	619			5.25								
2.30 p. m.		1,826,900	74.5		2.3	1.0			91,609	37,609	243	619			3.0								
2.45 p. m.	300																						
2.50 p. m.		1,832,810	75.0		2.3	1.0			93,619	39,619	243	619			5.5								
3.10 p. m.		1,838,710	75.0		2.3	1.1			95,628	41,628	243	619			6.5								
3.30 p. m.	300	1,844,420	74.5	31,943	2.2	.6			97,638	43,638	241	614			6.0								
3.50 p. m.		1,850,300	74.0		2.3	1.1			99,650	45,650	241	609			6.0								
4.10 p. m.		1,856,160	74.0		2.3	1.0			1,002	47,662	241	619			3.0								
4.30 p. m.	300	1,862,290	73.5		2.3	1.0			3,668	49,668	241	619			6.5								
4.50 p. m.		1,868,250	72.5		2.3	1.0			5,673	51,673	241	619			6.5								
5.10 p. m.		1,874,190	72.0		2.3	1.1			7,683	53,683	243	614			6.75								
5.30 p. m.		1,879,910	71.5	32,308	2.3	1.0			9,690	55,690	241	614			6.0								

α October 14.

PRODUCER-GAS TESTS.

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GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.	B. T. U. standard- ized.
12.20 p. m. ^a	7.4	0.0	16.8	5.5	6.1	64.2	100.0	142.7	150.7
1.20 p. m.	10.0	.0	12.4	3.1	6.3	68.2	100.0	120.2	137.4
2.20 p. m.	10.2	.0	11.4	4.6	6.1	67.7	100.0	120.7	127.5
3.20 p. m.	9.4	.0	16.0	6.5	4.6	63.5	100.0	127.5	134.6
4.20 p. m.	8.8	.2	16.4	13.1	5.0	56.5	100.0	156.1	164.9
8.20 a. m. ^b	6.0	.2	21.4	7.9	3.9	60.6	100.0	143.7	151.0
9 a. m.	7.6	.2	18.8	9.9	3.5	60.0	100.0	137.0	143.9
10 a. m.	7.2	.0	19.8	5.3	3.6	64.1	100.0	125.9	132.2
11 a. m.	7.4	.0	18.0	6.3	4.8	63.5	100.0	135.9	142.8
12 m.	8.2	.2	16.2	7.2	3.9	64.3	100.0	123.1	129.4
1 p. m.	8.6	.2	16.4	9.3	4.4	61.1	100.0	136.4	143.2
2 p. m.	9.0	.0	16.1	5.3	5.9	63.7	100.0	138.5	145.6
3 p. m.	8.8	.2	16.0	6.0	6.6	62.4	100.0	147.0	154.4
3.55 p. m. ^c	8.4	.2	17.0	7.1	7.1	60.2	100.0	159.6	167.6
7.55 a. m. ^d	6.4	.0	20.6	10.3	4.8	57.9	100.0	158.9	165.6
8.10 a. m.	4.4	.0	24.6	4.3	3.5	63.2	100.0	138.1	144.0
9.40 a. m.	7.0	.2	17.2	4.1	6.5	65.0	100.0	143.5	149.7
10.25 a. m.	7.4	.0	16.6	6.9	6.6	62.5	100.0	152.0	158.5
11.10 a. m.	7.8	.0	15.2	8.6	5.9	62.5	100.0	145.0	151.2
12.05 p. m.	7.6	.4	15.0	4.7	8.2	64.1	100.0	166.0	173.1
1.05 p. m.	7.7	.3	14.8	4.5	6.0	66.7	100.0	137.2	143.1
2 p. m.	7.8	.2	14.8	4.0	7.9	65.3	100.0	149.8	156.2
5 p. m.	9.0	.0	12.0	7.3	6.1	65.6	100.0	132.2	137.8
4.15 p. m.	9.2	.2	13.4	6.7	9.3	61.2	100.0	161.9	168.8
8.10 a. m. ^e	3.7	.0	23.9	11.4	4.8	56.2	100.0	174.2	179.0
9 a. m.	5.8	.0	18.2	8.3	7.7	60.0	100.0	174.4	179.2
9.50 a. m.	7.4	.0	16.7	1.2	5.6	69.1	100.0	122.0	125.4
10.45 a. m.	8.7	.3	12.8	7.9	4.4	65.9	100.0	119.0	122.3
11.40 a. m.	9.0	.0	11.8	11.0	5.6	62.6	100.0	139.0	142.9
12.30 p. m.	9.4	.0	12.0	5.0	6.2	67.4	100.0	125.3	128.8
1.30 p. m.	9.4	.0	12.2	12.6	7.8	58.0	100.0	169.2	173.8
2.30 p. m.	8.6	.0	13.1	5.8	9.7	62.8	100.0	141.3	145.2
3.30 p. m.	9.6	.2	13.0	6.1	9.3	61.8	100.0	166.6	171.3
4.30 p. m.	10.0	.0	12.0	2.1	9.4	66.5	100.0	149.3	153.4
8.10 a. m. ^f	5.2	.2	23.0	10.1	5.9	55.6	100.0	178.3	182.5
9 a. m.	7.8	.0	22.0	8.9	1.6	59.7	100.0	140.0	143.3
10 a. m.	7.8	.0	20.4	9.5	3.4	58.9	100.0	153.7	157.4
10.50 a. m.	8.2	.1	19.1	13.3	3.5	55.8	100.0	150.0	153.5
11.40 a. m.	8.4	.2	17.0	8.5	6.0	59.9	100.0	153.0	156.6
12.45 p. m.	9.6	.0	13.9	3.7	8.0	64.8	100.0	147.5	151.0
1.35 p. m.	9.8	.2	19.2	8.0	3.6	59.2	100.0	133.3	136.4
2.30 p. m.	10.0	.0	19.4	7.0	2.8	60.8	100.0	121.9	124.8
3.40 p. m.	9.2	.4	18.4	8.1	4.1	59.8	100.0	136.1	139.3
4.30 p. m.	10.0	.2	18.0	9.8	2.3	59.7	100.0	121.5	124.4

^a October 10.
^b October 11.

^c Gas sample taken from cock back of gas engine.
^d October 12.

^e October 13.
^f October 14.

OPERATIONS OF THE COAL-TESTING PLANT.

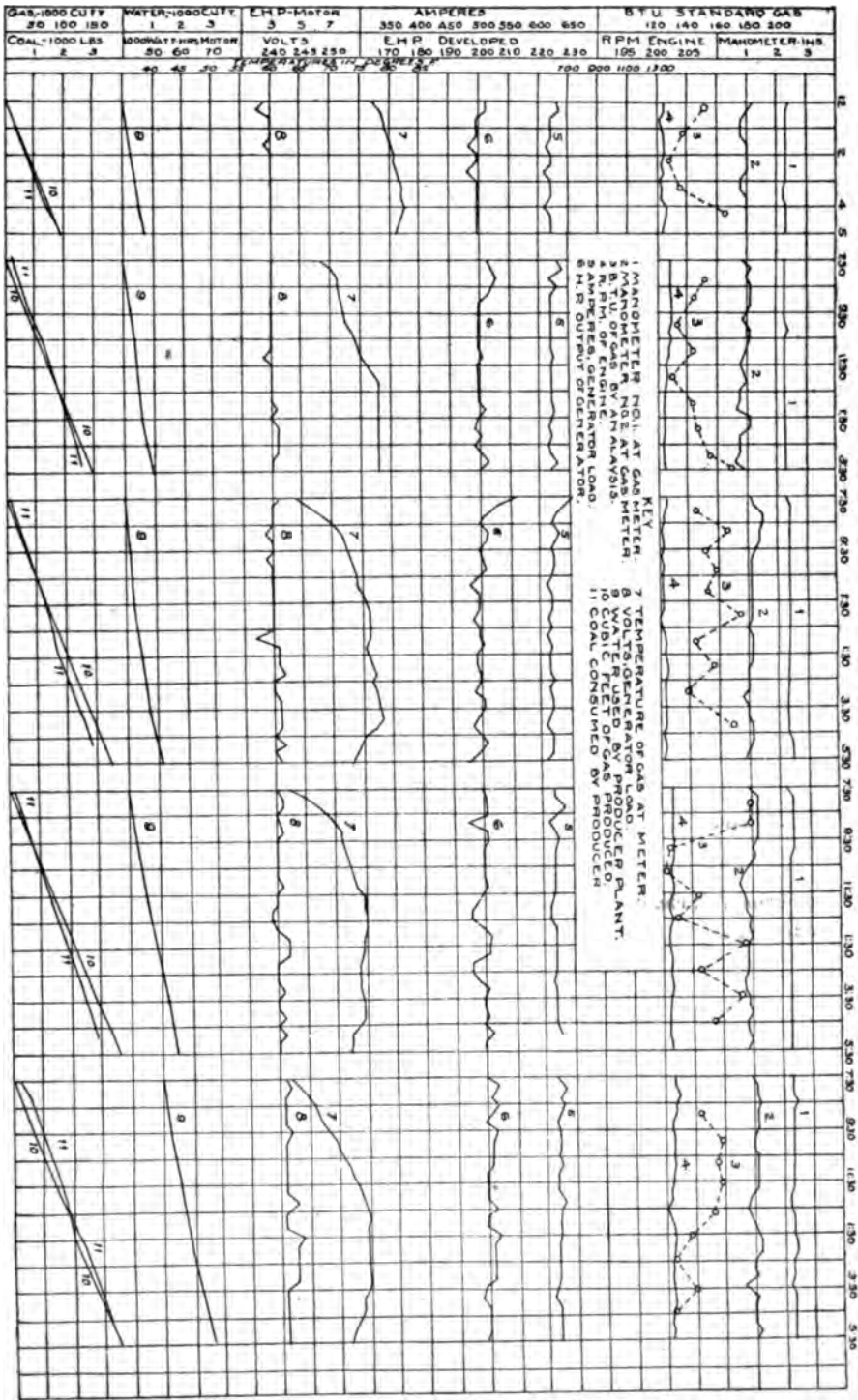
Producer-gas test No. 2, Alabama No. 2 coal.

[Recorded by M. H. Mount and R. E. Peshak, October 10-14, 1904.]

1. Duration of test, in hours	43
AVERAGE TEMPERATURE, ° F.	
2. Gas leaving producer	
3. Gas leaving economizer "	
4. Gas entering holder	
5. Air entering economizer	
6. Air leaving economizer	
OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
7. Total steam used by producer pounds..	9,200
8. Steam used by producer per hour do....	214
9. Equivalent in pounds of coal per hour	30.9
10. Equivalent in pounds of dry coal per hour	29.7
11. Equivalent in pounds of combustible per hour	26.8
12. Average horsepower required to drive auxiliary machinery	8
13. Total water used in scrubber and tar extractor cubic feet..	5,979
14. Cubic feet of water per hour per horsepower of producer plant	.56
15. Cubic feet of water per 1,000 cubic feet of gas produced	7.72
COAL CONSUMED IN PRODUCER.	
16. Total coal consumed..... pounds..	13,350
17. Moisture in coal per cent..	3.76
18. Total dry coal consumed..... pounds..	12,848
19. Refuse from dry coal..... per cent..	9.85
20. Total refuse from coal..... pounds..	1,350
21. Total combustible consumed..... do....	12,035
COAL PER HOUR.	
22. Coal consumed in producer..... pounds..	310.5
23. Dry coal consumed in producer do....	299
24. Combustible consumed in producer do....	280
25. Equivalent coal used by producer plant do....	341.4
26. Equivalent dry coal used by producer plant do....	328.7
27. Equivalent combustible used by producer plant..... do....	306.8
FUEL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.	
28. Coal as fired.....	8.07
29. Dry coal.....	7.78
30. Combustible	7.28

^a By special request of R. D. Wood & Co., the manufacturers of the gas producer, the temperatures indicated by items 3, 4, 5, and 6 were not taken during these preliminary tests.

FIG. 111.—Graphic log sheet, producer-gas test, Alabama No. 2 coal.



OPERATIONS OF THE COAL-TESTING PLANT.

COAL PER HOUR.

22. Coal consumed in producer.....	pounds..	364.4
23. Dry coal consumed in producer.....	do....	290.7
24. Combustible consumed in producer.....	do....	269.3
25. Equivalent coal used by producer plant.....	do....	428.4
26. Equivalent dry coal used by producer plant.....	do....	341.7
27. Equivalent combustible used by producer plant.....	do....	316.6

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired.....	9.48
29. Dry coal.....	7.56
30. Combustible.....	7.00

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	9,767
32. Per pound of dry coal.....	12,245
33. Per pound of combustible.....	13,210
34. From coal as fired, per hour.....	3,560,000
35. From dry coal, per hour.....	3,560,000
36. From combustible, per hour.....	3,560,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	460,300
38. Per hour.....	15,343
39. Per pound coal consumed in producer.....	42.1
40. Per pound dry coal consumed in producer.....	52.8
41. Per pound combustible consumed in producer.....	57.0
42. Per pound equivalent coal used by producer plant.....	35.8
43. Per pound equivalent dry coal used by producer plant.....	44.9
44. Per pound equivalent combustible used by producer plant.....	48.5

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	149
46. Per pound dry coal burned in producer.....	7,860
47. Per hour per brake horsepower.....	9,700

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	186.4
49. Electrical horsepower developed at switch board.....	200.2
50. Brake horsepower available for outside purposes.....	219.3
51. Brake horsepower developed at engine.....	235.4

EFFICIENCIES.

52. Of conversion and cleaning gas.....	.642
53. Of producer plant.....	.543

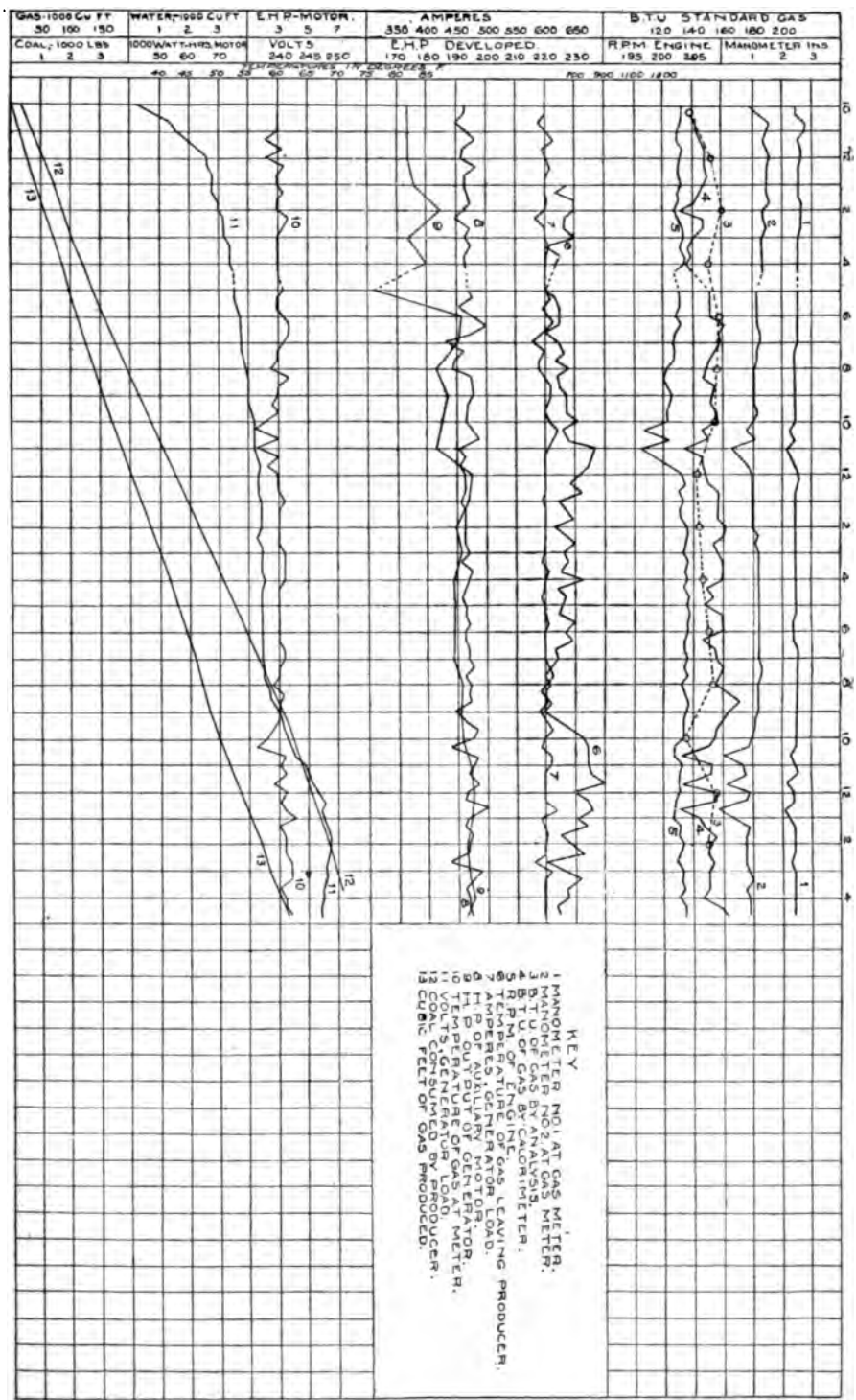


FIG. 112.—Graphic log sheet, producer-gas test, Colorado No. 1 coal.

OPERATIONS OF THE COAL-TESTING PLANT.

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes	1.95	1.56	1.45
55. Pounds consumed in producer per electrical horsepower developed at switch board	1.82	1.45	1.35
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes	1.66	1.32	1.23
57. Pounds consumed in producer per brake horsepower ^a developed at engine	1.55	1.23	1.14
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	2.30	1.83	1.70
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board	2.14	1.71	1.58
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes	1.95	1.56	1.44
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine	1.82	1.45	1.34

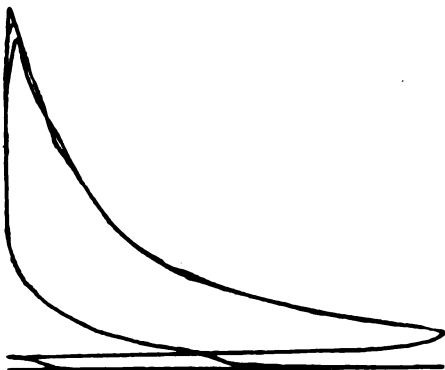
^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

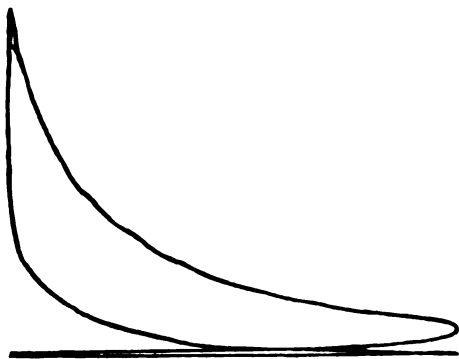
62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture	20.24	Carbon dioxide (CO ₂)	10.11
Volatile matter	32.26	Oxygen (O ₂)	.55
Fixed carbon	41.65	Carbon monoxide (CO)	17.38
Ash	5.85	Hydrogen (H ₂)	11.05
	100.00	Methane (CH ₄)	5.00
		Nitrogen (N ₂)	55.91
Sulphur	.60		100.00

GAS ENGINE.

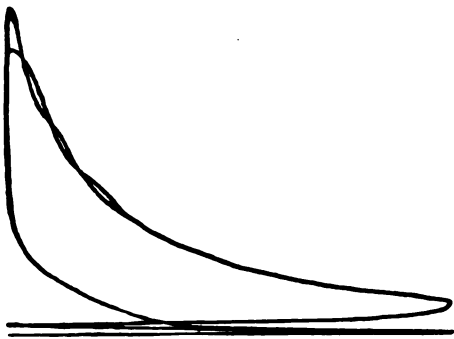
From 4.25 p. m. to 4.45 p. m. December 13 the engine was shut down in order to change the indicator cocks. The old cocks leaked badly, thus causing back firing. The test was continued until 4.40 p. m. December 14, making a full thirty-hour test.



Right cylinder. M. E. P., 58; Max., 300; Rel., 32; I. H. P., 83.2.



Center cylinder. M. E. P., 56; Max., 280; Rel., 26; I. H. P., 80.



Left cylinder. M. E. P., 56; Max., 280; Rel., 30; I. H. P., 80.

Indicator diagrams taken December 14, 1904, during gas-engine test No. 15, on Colorado No. 1 coal. Scale of spring, 80; revolutions per minute, 204.

Report of gas-engine test No. 15.

Recorded by K. Toensfeldt and W. C. Weidmann December 13 and 14, 1904.	
Producer test No. 15.	
Coal: General number, Colorado No. 1; special number, G. P. 15. Car initials and number, C., B. and Q. 81529.	
Duration of test, in hours.....	30
Revolutions per minute (mean).....	202.8
Explosions per minute (mean).....	101.4
Cubic feet gas per hour, by meter.....	15,183
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	15,333
Maximum pressure:	
First cylinder	260.7
Second cylinder	270.3
Third cylinder.....	258
Pressure at release:	
First cylinder	29.95
Second cylinder	29.31
Third cylinder.....	27.40
Mean effective pressure:	
First cylinder	58.43
Second cylinder	58.50
Third cylinder.....	52.46
Indicated horsepower:	
First cylinder	92.92
Second cylinder	93.30
Third cylinder.....	84.20
Total indicated horsepower	270.42
Horsepower delivered (electrical horsepower)	200.2
Mechanical efficiency (engine and generator combined).....per cent..	74.1
Cubic feet standard gas per hour per indicated horsepower.....	56.7
Cubic feet standard gas per hour per electrical horsepower	76.7

ILLINOIS No. 3.

GENERAL RESULTS.

The general results of Illinois No. 3 coal are shown in the following tables:

Log of producer-gas test No. 6, Illinois No. 3 coal, October 31, November 1, 1904.

[Coal from mine No. 3 of the Southern Illinois Coal Mining and Washing Company, located near Marion, Ill.]

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		* Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Gas calorimeter.						
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercury).	Gas leaving (inches water).	Temperatures (° C.).			Cubic centimeters of water collected.	Cubic feet of gas.	As read.	B. T. U. Standardized.
																Gas.	Inlet.	Outlet.				
1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
9.30 a. m.	300	3,173,110	56.0	57,222	2.0	0.3																
9.50 a. m.		3,179,800	58.0		2.3	1.0																
10 a. m.	300						98,490															
10.10 a. m.		3,185,732	61.5	57,270	2.3	1.1																
10.20 a. m.																						
10.30 a. m.		3,191,150	64.0		2.4	1.4																
10.40 a. m.																						
10.45 a. m.	300																					
10.50 a. m.		3,196,400	66.0		2.4	1.4	100,140															
11 a. m.																						
11.20 a. m.		3,201,750	67.0		2.4	1.3																
11.30 a. m.		3,207,400	67.5	57,340	2.3	1.3																
11.40 a. m.																						
11.45 a. m.	300																					
11.50 a. m.		3,213,050	67.5		2.3	1.3	101,590															
12 m.																						
12.10 p. m.		3,218,750	67.0		2.4	1.3																
12.20 p. m.																						
12.30 p. m.		3,224,160	67.0		2.4	1.3																
12.45 p. m.	300																					
12.50 p. m.		3,229,700	68.0		2.4	1.2	103,000															
1 p. m.																						
1.05 p. m.																						

October 31, 9.30 a. m., to 7.10 a. m. November 1, barometer 29.77 inches.

Log of producer-gas test No. 6, Illinois No. 3 coal, October 31, November 1, 1904—Continued.

Time.	(Coal consumed by producer (pounds).		(Gas meter (cubic feet).		Temperature of gas (° F.).		Water meter (cubic feet).		Manometer at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Gas calorimeter.								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Cubic feet of gas.		B. T. U.							
								Ammeter.		Watt meter.				Volts.		Amperes.		Air entering (inches mercury).		Gas leaving (inches water).		Temperatures (° C.).		Cubic centimeters of water collected.		As read.		Standardized.	
1.10 p. m.		3,295,350	68.5		2.4	1.2			57,020	97,020	241	614	360																
1.25 p. m.								18.0																					
1.30 p. m.		3,240,980	67.5	57,431	2.4	1.2		19.0	59,030	99,030	241	619	385																
1.45 p. m.	300																												
1.50 p. m.		3,246,650	67.5		2.4	1.2		25.0	61,038	1,038	237	619	415	0.4	5.0														
2 p. m.							104,360																						
2.10 p. m.		3,252,300	68.0		2.4	1.2		18.0	63,017	3,047	241	619	390																
2.30 p. m.		3,257,950	68.0		2.4	1.2		18.0	65,056	5,056	240	614	405																
2.35 p. m.	300																												
2.50 p. m.		3,263,760	69.0		2.3	1.1		23.0	67,062	7,062	242	629	360	.5	6.5														
3 p. m.							105,780																						
3.10 p. m. ^a		3,269,440	69.5		2.4	1.2		18.0	69,076	9,076	240	619	383																
3.30 p. m.				57,508					70,941	10,941																			
3.45 p. m.																													
3.50 p. m.									72,741	12,741																			
3.55 p. m.	300						106,400																						
4 p. m.																													
4.05 p. m.																													
4.10 p. m.		3,279,500	68.0		2.3	.7		23.0	74,070	14,070	240	629	370	.5	5.8														
4.25 p. m.																													
4.30 p. m.		3,285,420	68.0		2.4	1.2		17.0	76,081	16,081	240	619	400																
4.45 p. m.																													
4.50 p. m.	300	3,291,090	67.0		2.3	1.1		17.0	78,689	18,689	238	614	410																
5 p. m.							107,700																						
5.05 p. m.																													
5.10 p. m.																													
5.15 p. m.																													
5.20 p. m.																													
5.25 p. m.																													
5.30 p. m.																													
5.35 p. m.																													
5.40 p. m.																													
5.45 p. m.																													
5.50 p. m.																													
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9.45 p. m.																													
9.50 p. m.																													
9.55 p. m.																													
10.00 p. m.																													
10.05 p																													

^a3.14 p. m. load was removed from engine in order to repair hose connection to tar extractor. The load was added to the end of the test to make an even thirty-hour run.

Log of producer-gas test No. 6, Illinois No. 3 coal, October 31, November 1, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Temperature (° C.).				Gas calorimeter.		B. T. U.	
				5	6	1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	13	14	Air entering (inches mercury).	15	16	Gas.	Water.		Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.
																				Inlet.	Outlet.				
1	2	3	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24				
9.05 p. m.																									
9.10 p. m.		3,365,850	64.0		2.4	1.0		18.0	4,889	44,889	240	609	410						15.5	13.50	20.29	1,130	0.2	152.0	152.3
9.25 p. m.																									
9.30 p. m.	300	3,371,620	63.5	57,906	2.4	1.0		25.0	6,905	46,905	240	619	420						14.0	13.40	20.60	1,230	.2	160.6	160.0
9.45 p. m.																									
9.50 p. m.		3,377,290	63.0		2.4	1.0		20.0	8,922	48,922	240	619	430						14.0	13.50	19.69	1,300	.2	159.5	158.9
10 p. m.								114,700																	
10.05 p. m.																			13.0	13.40	18.88	2,000	.3	144.8	143.9
10.10 p. m.		3,383,110	63.0		2.4	.9		17.0	10,985	50,985	239	614	500												
10.15 p. m.	300																								
10.25 p. m.																									
10.30 p. m.		3,389,310	63.5		2.4	1.0		23.0	12,944	52,944	240	619	380						12.0	13.40	18.31	2,100	.3	135.1	133.7
10.45 p. m.																									
10.50 p. m.		3,395,300	63.5		2.4	1.0		18.0	14,964	54,964	241	619	460						12.0	13.40	18.60	2,250	.3	154.7	153.2
11 p. m.	300							116,025																	
11.05 p. m.																									
11.10 p. m.		3,401,150	63.0		2.4	1.0		25.0	16,987	56,987	239	614	420						11.5	13.40	18.79	1,450	.2	152.0	150.5
11.25 p. m.																									
11.30 p. m.		3,406,950	63.0	56,063	2.3	1.1		16.0	19,007	59,007	240	614	420						11.0	13.40	18.60	1,500	.2	154.8	152.7
11.45 p. m.	300																								
11.50 p. m.		3,412,800	63.5		2.3	1.0		24.0	21,027	61,027	241	624	400						11.0	13.40	18.29	1,600	.2	155.5	153.3
12 p. m.								117,880																	
12.05 a. m.																			11.0	13.40	18.19	1,550	.2	147.6	145.6
12.10 a. m.		3,418,650	63.5		2.4	1.1		17.0	23,041	63,041	241	619	390						11.0	13.45	18.20	1,550	.2	146.0	143.9
12.25 a. m.																									

a November 1. Barometer 29.78 from 7.10 a. m. to end of test.

PRODUCER-GAS TESTS.

Time	Coal consumed by producer (pounds).	Gas calorimeter.															B. T. U.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
		Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer (inches water).			Temperatures (° C.).			Cubic feet of gas.	Cubic centimeters of water collected.	As read.	Standardized.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
				1.	2.	1.	2.	Volts.	Amperes.	14	15	16	Gas.	Inlet.	Outlet.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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																															Water meter.	Ammeter.	Watt meter.	1.	2.	1.	2.	17	18	19																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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a Short circuit in the rheostat. Load off from 12.50 a. m. to 1.03 a. m.

Log of producer-gas test No. 6, Illinois No. 3 coal, October 31, November 1, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.			Load.		Manometers at producer.	Gas calorimeter.				B. T. U.				
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	Air entering producer (° C.).		Temperature of gas leaving producer (° C.).	Inlet.	Outlet.	Cubic centimeters of water collected.		Cubic feet of gas.	As read.	Standardized.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
4.10 a. m.		3,486,400	60.5		2.4	1.2			22.0	47,106	87,106	241	614	460			13.0	13.8	19.00	1,350	0.2	139.3	138.3
4.25 a. m.					2.3	1.0		16.0	48,104	89,104	241	619	470	0.4	5.0		13.0	13.6	19.20	1,350	.2	150.0	149.0
4.30 a. m.	300	3,492,300	60.0																				
4.45 a. m.		3,498,310	60.5		2.4	1.	123,700	23.5	51,102	91,102	241	624	430				13.0	13.6	18.10	1,700	.2	150.0	149.0
5 a. m.																							
5.05 a. m.		3,504,230	61.0		2.3	1.0		19.0	53,100	93,100	241	629	430				13.0	13.7	18.22	1,700	.2	151.9	150.8
5.10 a. m.																							
5.25 a. m.	300	3,510,300	61.0	58,596	2.3	1.0		24.0	55,097	95,097	240	629	480	.4	6.0		13.0	13.6	18.20	1,650	.2	150.7	149.7
5.45 a. m.		3,516,250	61.0		2.3	9	125,010	23.0	57,097	97,097	241	614	400										
5.50 a. m.																							
6 a. m.																							
6.05 a. m.		3,522,180	61.0		2.3	.9		17.5	59,098	99,098	241	619	440				16.0	13.7	19.47	1,450	.2	166.6	167.2
6.10 a. m.																							
6.25 a. m.		3,528,050	60.0		2.4	1.0		21.0	61,098	1,098	241	619	390	.4	6.0		17.0	13.8	19.97	1,300	.2	159.9	161.2
6.30 a. m.	300																						
6.45 a. m.		3,533,810	60.0		2.4	1.1	126,250	17.5	63,100	3,100	241	579	360				17.0	13.8	20.65	1,300	.2	173.0	174.5
6.50 a. m.																							
7 a. m.																							
7.05 a. m.		3,539,600	60.5		2.4	1.1		18.0	65,102	5,102	238	619	420				16.5	13.6	20.50	1,150	.2	157.5	158.6
7.10 a. m.																							
7.25 a. m.		3,545,275	61.5	58,687	2.4	1.2		22.0	67,100	7,100	240	619	395	.5	5.2		16.5	13.6	20.20	1,100	.2	144.0	145.0
7.30 a. m.	300																						
7.45 a. m.		3,550,800	61.5		2.4	1.1	127,490	18.0	69,092	9,092	242	599	395				17.0	13.6	19.76	1,300	.2	159.9	161.2
7.50 a. m.																							
7.55 a. m.																							

Log of producer-gas test No. 6, Illinois No. 3 coal, October 31, November 1, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.				Gas calorimeter.								B. T. U.			
																						Temperatures (° C.).		Cubic feet of gas.		Cubic centimeters of water collected.		Cubic feet of gas.					
																						Water.		Inlet.		Outlet.		As read.					
																						Gas.	Inlet.	Outlet.	Gas.	Inlet.	Outlet.	As read.	Standardized.				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30				
8.05 a. m.																																	
8.10 a. m.		3,556,400	63.0		2.4	1.1		17.0	71,106	11,106	239	619	440			17.0	13.6	20.06	1,250	0.2	161.1	162.4											
8.25 a. m.																																	
8.30 a. m.	300	3,562,110	64.5		2.4	1.0		22.5	73,124	13,124	240	619	365			19.0	13.6	20.26	1,200	.2	158.7	161.3											
8.45 a. m.																																	
8.50 a. m.		3,567,790	66.5		2.4	1.1		15.0	75,139	15,139	240	619	400	0.5	6.0	19.0	14.0	21.18	1,150	.2	164.2	166.9											
9 a. m.							128,650																										
9.05 a. m.																																	
9.10 a. m.		3,573,590	68.0		2.4	1.1		16.0	77,156	17,156	240	619	435			21.0	14.0	21.00	1,150	.2	159.9	163.5											
9.25 a. m.	300																																
9.30 a. m.		3,579,330	68.5	58,755	2.4	1.0		20.0	79,167	19,167	240	619	400			24.0	18.4	25.20	1,150	.2	155.1	160.1											
9.45 a. m.																																	
9.50 a. m.		3,585,160	71.5		2.4	1.1		17.0	81,178	21,178	240	619	405			27.0	13.8	21.11	1,100	.2	159.5	166.3											
10.05 a. m.																																	
10.10 a. m.		3,591,210	73.0		2.3	.9		17.0	83,187	23,187	240	619	400			26.0	13.7	20.04	1,150	.2	167.5	163.0											
10.25 a. m.	300																																
10.30 a. m.		3,597,310	75.0		2.3	.9		22.0	85,209	25,209	240	614	350			26.0	13.8	21.00	1,050	.2	150.0	155.8											
10.45 a. m.																																	
10.50 a. m.		3,603,350	75.0		2.3	.9		17.0	87,231	27,231	240	619	400			28.0	14.0	21.60	1,050	.2	158.3	165.7											
11 a. m.							131,100																										
11.05 a. m.																																	
11.10 a. m.		3,609,310	75.0		2.3	1.1		22.0	89,244	29,244	237	619	395	5	5.5	28.0	18.8	26.10	1,450	.3	140.9	147.5											
11.15 a. m. ^a	300																																
11.25 a. m.																																	
11.30 a. m.		3,615,410	76.0	58,871	2.3	1.0		22.0	91,257	31,257	240	619	380			28.0	14.2	21.65	1,050	.2	155.1	162.4											

^aOne igniter was "off" from 11.20 to 11.25.

Log of producer-gas test No. 6, Illinois No. 3 coal, October 31, November 1, 1904—Continued.

Time.		(Coal consumed by producer (pounds).	(Gas meter (cubic feet).	Temperature of gas (° F.).	Manome- ters at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manome- ters at pro- ducer.		Gas calorimeter.						B. T. U.		
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mer- cury).	Gas leaving (inches wa- ter).	Temperatures (° C.).		Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.			
																Gas.	Inlet.							Outlet.
1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
11.45 a. m.		3,621,500	77.0		2.3	0.9			17.0	93,274	33,274	241	619	400			29.0	14.2	21.91	1,050	0.2	160.3	168.4	
11.50 a. m.								132,310																
12.05 p. m.	300	3,627,700	77.0		2.3	.8			21.0	95,284	35,284	241	619	410	0.2	5.0	28.5	14.2	21.60	1,000	.2	146.8	153.9	
12.10 p. m.																								
12.25 p. m.		3,633,790	76.5		2.3	.9			16.5	97,300	37,300	240	619	410			27.0	14.2	21.37	1,050	.2	151.9	158.3	
12.30 p. m.																								
12.45 p. m.	300	3,640,050	77.0		2.3	.9			21.0	99,314	39,314	240	624	380	.4	5.5	28.0	14.2	21.36	1,050	.2	150.0	156.9	
12.50 p. m.	300							133,600																
1 p. m.		3,646,400	78.0		2.3	.9			19.0	1,314	41,314	240	629	400			28.0	14.1	21.00	1,100	.2	150.7	157.5	
1.05 p. m.																								
1.10 p. m.		3,652,900	78.5	58,981	2.2	.8			22.0	3,310	43,310	239	634	420			28.0	14.2	20.80	1,100	.2	144.0	150.6	
1.30 p. m.	300																							
1.45 p. m.		3,659,410	80.0		2.2	.5			16.5	5,309	45,309	240	619	420			27.5	14.0	20.10	1,350	.2	163.4	170.5	
1.50 p. m.								134,950																
2 p. m.																								
2.05 p. m.		3,665,990	81.0		2.2	.4			22.0	7,310	47,310	240	619	420	.4	6.5	27.0	14.1	20.00	1,350	.2	157.9	164.7	
2.10 p. m.	300																							
2.20 p. m.																								
2.25 p. m.		3,672,520	81.0		2.2	.4			17.5	9,308	49,308	240	609	410	.25	6.0	27.5	14.1	19.10	1,300	.2	128.9	134.6	
2.30 p. m.																								
2.45 p. m.		3,679,120	81.5		2.2	.4			22.0	11,309	51,309	239	629	320			27.0	14.1	19.07	1,350	.2	132.9	138.6	
2.50 p. m.	300							136,200																
3 p. m.																								
3.05 p. m.																	27.0	14.0	19.00	1,350	.2	134.1	139.8	

OPERATIONS OF THE COAL-TESTING PLANT.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
9.55 a. m. ^a	6.5	0.3	19.2	2.3	4.1	67.6	100.0	118.7
11.55 a. m.	8.0	1.0	20.2	9.1	3.4	58.3	100.0	138.4
1.30 p. m.	9.4	.0	18.4	7.9	3.5	60.8	100.0	129.0
3.45 p. m.	10.4	.6	17.0	4.9	3.4	63.7	100.0	112.6
5.30 p. m.	8.0	.6	19.0	11.8	1.3	59.3	100.0	121.2
7.30 p. m.	9.6	.2	16.8	12.1	4.2	57.1	100.0	145.5
9.30 p. m.	10.4	.6	16.6	6.9	4.0	61.5	100.0	124.5
11.30 p. m.	11.0	.2	16.4	6.0	4.1	62.3	100.0	121.8
1.30 a. m. ^b	10.8	.0	16.2	12.8	3.5	56.7	100.0	133.8
3.30 a. m.	10.4	.0	16.6	11.1	3.5	58.4	100.0	133.8
5.30 a. m.	10.2	.2	15.6	8.3	3.6	62.1	100.0	120.6
7.30 a. m.	10.2	.0	16.6	11.8	3.1	58.3	100.0	132.0
9.30 a. m.	9.2	.0	13.6	10.0	5.6	61.6	100.0	141.9
11.30 a. m.	11.2	.0	12.4	12.4	5.6	58.4	100.0	146.1
1.30 p. m.	11.8	.2	11.6	2.4	6.7	67.3	100.0	120.2
3.30 p. m.	12.2	.0	11.6	2.0	7.2	67.0	100.0	124.1

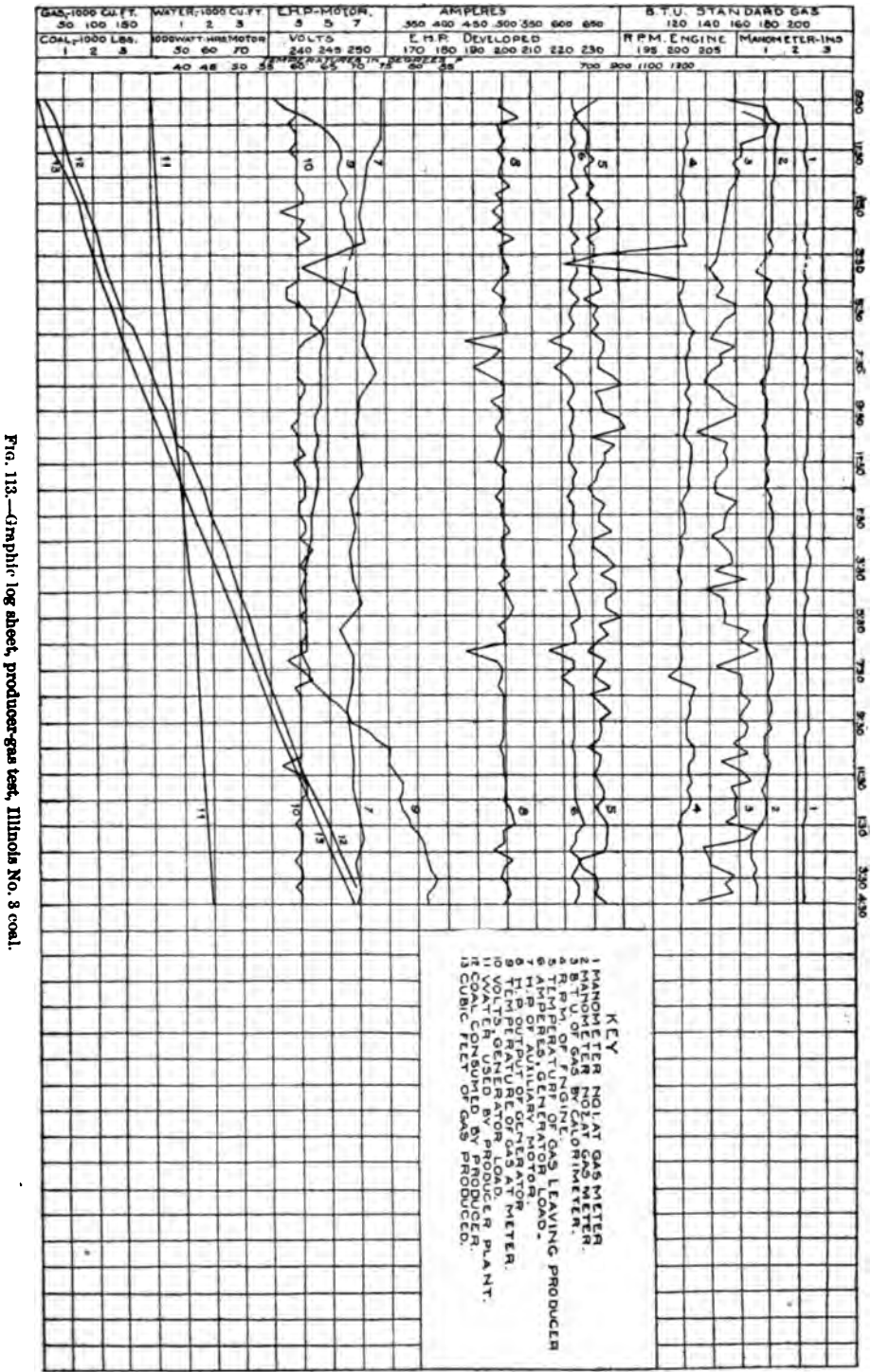
^a October 31. ^b November 1.

Producer-gas test No. 6, ^a Illinois No. 3 coal.

[Recorded by M. H. Mount and R. E. Peshak, October 31–November 1, 1904.]

1. Duration of test, in hours	30
AVERAGE TEMPERATURE, ° F.	
2. Gas leaving producer	753
3–6. (See footnote on p. 1027.)	
OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
7. Total steam used by producer	6,690 pounds.
8. Steam used by producer per hour	223 do.
9. Equivalent in pounds of coal per hour	36
10. Equivalent in pounds of dry coal per hour	33.4
11. Equivalent in pounds of combustible per hour	29.9
12. Average horsepower required to drive auxiliary machinery	7.1
13. Total water used in scrubber and tar extractor	1,828 cubic feet.
14. Cubic feet of water per hour per horsepower of producer plant	.244
15. Cubic feet of water per 1,000 cubic feet of gas produced	3.5
COAL CONSUMED IN PRODUCER.	
16. Total coal consumed	10,500 pounds.
17. Moisture in coal	7.62 per cent.
18. Total dry coal consumed	9,700 pounds.
19. Refuse from dry coal	10.53 per cent.
20. Total refuse from coal	1,021 pounds.
21. Total combustible consumed	8,679 do.

^a Gas-producer hopper leaked.



OPERATIONS OF THE COAL-TESTING PLANT.

COAL PER HOUR.

22. Coal consumed in producer.....	pounds..	350
23. Dry coal consumed in producer	do....	323. 3
24. Combustible consumed in producer.....	do....	289. 3
25. Equivalent coal used by producer plant.....	do....	386
26. Equivalent dry coal used by producer plant.....	do....	356. 7
27. Equivalent combustible used by producer plant	do....	319. 2

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired	9. 10
29. Dry coal	8. 41
30. Combustible	7. 53

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	12, 046
32. Per pound of dry coal	13, 041
33. Per pound of combustible.....	14, 560
34. From coal as fired, per hour.....	4, 215, 000
35. From dry coal, per hour	4, 215, 000
36. From combustible, per hour	4, 215, 000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total	522, 350
38. Per hour.....	17, 412
39. Per pound coal consumed in producer	49. 8
40. Per pound dry coal consumed in producer	53. 9
41. Per pound combustible consumed in producer.....	60. 2
42. Per pound equivalent coal used by producer plant.....	45. 1
43. Per pound equivalent dry coal used by producer plant	48. 8
44. Per pound equivalent combustible used by producer plant	54. 5

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	154. 8
46. Per pound dry coal burned in producer.....	8, 330
47. Per hour per brake horsepower	11, 460

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes	192. 5
49. Electrical horsepower developed at switch board	199. 6
50. Brake horsepower available for outside purposes	226. 5
51. Brake horsepower developed at engine	235

EFFICIENCIES.

52. Of conversion and cleaning gas	. 640
53. Of producer plant	. 578

PRODUCER-GAS TESTS.

1055

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes	1.82	1.68	1.50
55. Pounds consumed in producer per electrical horsepower developed at switch board	1.75	1.62	1.45
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes	1.54	1.43	1.28
57. Pounds consumed in producer per brake horsepower ^a developed at engine	1.49	1.38	1.23
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	2.01	1.85	1.66
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board	1.93	1.79	1.60
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes	1.70	1.58	1.41
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine	1.64	1.52	1.36

^aBased on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

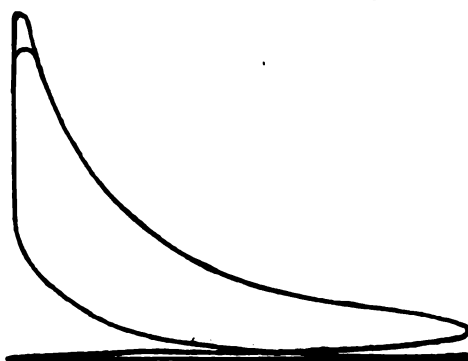
62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture	7.62	Carbon dioxide (CO ₂)	10.53
Volatile matter	30.87	Oxygen (O ₂)	.15
Fixed carbon	51.78	Carbon monoxide (CO)	15.31
Ash	9.73	Hydrogen (H ₂)	8.35
	100.00	Methane (CH ₄)	4.46
Sulphur	1.69	Nitrogen (N ₂)	61.20
			100.00

GAS ENGINE.

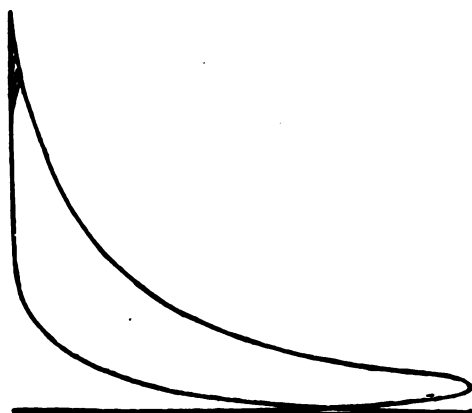
Owing to the necessity of repairing the hose connections from the water-supply pipe to the tar extractor, the load was taken off the engine for forty minutes at 3.14 p. m. October 31. In order to make the full thirty-hour test, the time lost was added to the latter part of the run. In making up the report a full hour was deducted for the interruption in the continuity of the test.

The test on this coal was very satisfactory. The gas was good and the coal easily handled. There were no signs of clinkers in the fire, and it is certain that this coal could be used continuously without trouble from that source. It may be considered a good gas-producer coal.

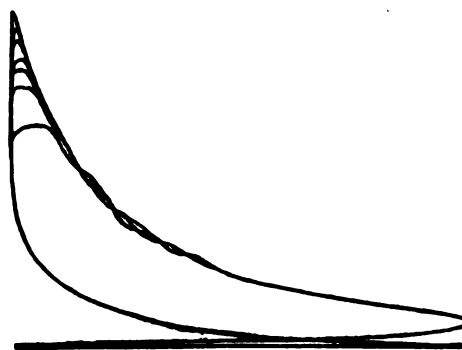
Sixty gallons of tar were extracted during the run.



Right cylinder M. E. P., 57.5; Max., 260; Rel., 31; I. H. P., 91.1.



Center cylinder. M. E. P., 56; Max., 304; Rel., 30; I. H. P., 88.6.



Left cylinder. M. E. P., 52; Max., 262; Rel., 28; I. H. P., 82.3.

Indicator diagrams taken October 31, 1904, during gas-engine test No. 6, on Illinois No. 3 coal. Scale of spring, 80; revolutions per minute, 201.

Report of gas-engine test No. 6.

Recorded by R. W. Cummings and W. C. Weidmann, October 31–November 1, 1904.

Producer test No. 6.

Coal: General number, Illinois No. 3; special number, G. P. 6. Car initials and number, C. and E. I. 14250.

Duration of test, in hours.....	30
Revolutions per minute (mean).....	200.9
Explosions per minute (mean).....	100.4
Cubic feet gas per hour, by meter.....	17,607
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	17,395
Maximum pressure:	
First cylinder.....	266.1
Second cylinder.....	286.8
Third cylinder.....	242.4
Pressure at release:	
First cylinder.....	30.26
Second cylinder.....	30
Third cylinder.....	27.7
Mean effective pressure:	
First cylinder.....	61.23
Second cylinder.....	57.66
Third cylinder.....	50.46
Indicated horsepower:	
First cylinder.....	96.92
Second cylinder.....	91.26
Third cylinder.....	80.03
Total indicated horsepower.....	268.21
Horsepower delivered (electrical horsepower).....	199.6
Mechanical efficiency (engine and generator combined)..... per cent..	74.4
Cubic feet standard gas per hour per indicated horsepower.....	64.8
Cubic feet standard gas per hour per electrical horsepower.....	87.1

ILLINOIS No. 4.

GENERAL RESULTS.

The general results of tests of Illinois No. 4 coal are shown in the following tables:

Log of producer-gas test No. 9, Illinois No. 4 coal, November 10, 11, 1904.
[Coal from mine No. 3 of the Donk Brothers' Coal and Coke Company, Troy, Ill.]

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer (inches mercury).		Temperatures (° C.).				Gas calorimeter.		B. T. U.
				1	2	1	2	Watt meter.	Ammeter.	1	2	Volts.	Ampers.	13	14	15	16	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.
8.30 a. m. a.	300									10	11	12	13	14	15	16	17	18	19	20	21	22	23	
8.45 a. m. b.		4,636,930	52.0	74,786		2.3	0.9		28.0			48,020	239	629	619	0.6	6.0							(d)
9.05 a. m.		4,642,830	53.5			2.3	.9		29.0			50,066	238	619										
9.25 a. m.		4,648,500	54.0			2.4	1.0	236,380	27.5			52,153	239	619										
9.45 a. m.		4,653,860	55.5			2.3	1.0		27.5			54,210	239	619										
10 a. m.	300																							
10.05 a. m.		4,660,730	55.5			2.3	.9		28.0			56,268	239	619										
10.25 a. m.		4,665,720	55.5			2.3	.9	238,000	25.0			58,355	239	614		6	6.0							
10.45 a. m.		4,671,580	56.5	74,958		2.3	.9		27.0			50,398	240	619										
11 a. m.	300																							
11.05 a. m.		4,677,480	57.0			2.3	.9		29.0			62,463	240	614	500									
11.25 a. m.		4,683,400	57.0			2.3	.9	239,850	27.5			64,594	241	619	450	.5	6.5							
11.45 a. m.	300	4,689,200	57.5			2.3	.9		28.0			66,594	239	599	470									
12.05 p. m.		4,696,180	57.0			2.4	.9		25.0			68,656	240	624	400									
12.25 p. m.		4,701,130	57.0			2.5	.8		25.0			70,721	240	619	440	6	7.0							
12.30 p. m.	300																							
12.45 p. m.		4,706,750	57.0	75,130		2.5	.8	242,020	28.0			72,779	241	619	420									
1.05 p. m.		4,712,250	58.0			2.4	.9		25.5			74,837	241	614	410	6	6.0							
1.25 p. m.		4,717,840	58.0			2.4	1.2		28.0			76,883	242	599	450									
1.30 p. m.	300																							
1.45 p. m.		4,723,900	58.0			2.4	1.2	243,780	28.0			78,965	243	619	400		6	6.0						
2.05 p. m.		4,729,640	58.0			2.4	1.2		28.0			80,999	241	619	420									
2.25 p. m.		4,735,410	58.0			2.4	1.2	244,920	28.0			81,080	240	619	420									

^a November 10.
^b 8.45 a. m. to 4.05 p. m., barometer 29.67 inches.
^c Pyrometer connection broken until 10.45 a. m.
^d B. T. U. determined from analyses for the entire test.

Log of producer-gas test No. 9, Illinois No. 4 cont., November 10, 11, 1904—Continued.

Time.	(Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Manometers at gas meter (inches water).		Auxiliary motor.		Speed counters on gas engine.	Load.	Temperature of gas leaving producer (° C.).	Manometers at producer.		Temperatures (° C.).		Gas calorimeter.		B. T. U.						
				1.	2.	Watt meter.	Ammeter.				1.	2.	Volts.	Amperes.	Air entering (inches mer- cury).	Gas leaving (inches wa- ter).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.
1				6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
2.30 p. m.	300																						
2.45 p. m.		4,741,360	58.0	2.4	1.1		27.0	63,143	84,143	241	619	410	0.5	6.0									
3.05 p. m.		4,747,420	57.0	2.5	1.2		28.0	(a)	86,201	240	614	440											
3.15 p. m.	300																						
3.25 p. m.		4,753,370	58.0	2.5	1.2	246,700	28.0	67,064	88,264	240	619	400	.6	6.0									
3.45 p. m.		4,759,260	58.0	2.4	1.2		27.0	69,126	90,326	240	619	410											
4 p. m.	300																						
4.05 p. m. ^b		4,765,180	57.5	2.4	1.2		27.0	71,183	92,383	240	624	420											
4.25 p. m.		4,770,840	58.0	2.4	1.2	248,440	27.0	73,245	94,445	240	619	400											
4.45 p. m.		4,776,620	58.0	2.4	1.4		27.0	75,204	96,404	241	619	480	.6	6.0									
5 p. m.	300																						
5.05 p. m.		4,782,520	58.0	2.4	1.1		27.0	77,363	98,563	241	634	480											
5.25 p. m.		4,788,390	58.0	2.4	1.2	250,110	26.0	79,428	628	242	629	460											
5.45 p. m.	300	4,794,020	58.0	2.4	1.2		26.0	81,452	2,652	242	619	450	.6	6.0									
5.05 p. m.		4,798,750	58.5	2.3	1.1		27.0	83,475	4,675	243	614	430											
6.25 p. m.		4,805,160	59.0	2.4	1.2		27.0	85,491	6,691	243	619	430	.56	7.0									
6.45 p. m.										241	619	420											
6.45 p. m.	300	4,810,500	58.0	2.5	1.3		27.5	87,516	8,716														
7.05 p. m.		4,816,060	57.0	2.5	1.1		26.0	89,540	10,740	240	619	410	.6	7.0									
7.25 p. m.		4,821,600	57.0	2.5	1.2	253,500	22.0	91,566	12,766	239	609	460											
7.45 p. m.	300	4,827,400	57.5	2.4	1.0		25.0	93,573	14,773	241	619	510											
8.05 p. m.		4,833,300	57.0	2.5	1.1		30.0		16,780	240	619	430	.6	7.0									
8.25 p. m.		4,838,760	57.0	2.5	1.2	255,760	30.0	95,503	18,803	239	619	460											
8.45 p. m.	300	4,844,150	57.0	2.5	1.3		25.0	97,525	20,925	240	619	420											
9.05 p. m.		4,849,510	57.0	2.5	1.3		30.0	99,545	22,945	241	619	410											

Speed counter No. 1 out of order.

November 10, 4.05 p. m. to 8.05 a. m. November 11 barometer 29.86 inches

^a Speed counter No. 1 out of order.

^b November 10, 4.05 p. m. to 8.05 a. m. November 11, barometer 29.86 inches

Log of producer-gas test No. 9, Illinois No. 4 coal, November 10, 11, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.			Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Gas calorimeter.				B. T. U.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
9.25 p. m.	300	4,854,850	57.0		2.5	1.4	256,870	24.0	1,565	24,985	240	609	410	0.55	6.0								
9.45 p. m.	300	4,860,320	56.5		2.5	1.3		23.0	3,586	28,985	240	614	470										
10.05 p. m.		4,865,650	56.5		2.5	1.3		25.0	5,807	29,007	240	619	440										
10.25 p. m.		4,871,090	56.5		2.5	1.2	258,500	24.0	7,627	31,027	239	619	470	.55	6.0								
10.45 p. m.	300	4,876,660	56.5	76.243	2.5	1.2		29.0	9,641	33,041	239	619	440										
11.05 p. m.		4,882,270	56.0		2.4	1.1		25.0		35,058	240	619	460										
11.25 p. m.		4,887,990	56.0		2.4	1.0	280,150	25.0	11,069	37,069	240	619	450										
11.30 p. m.	300																						
11.45 p. m.		4,893,810	56.5		2.4	1.0		31.0	13,090	39,090	240	619	410	.55	6.0								
12.05 a. m.		4,899,450	55.0		2.4	1.1		25.0	15,110	41,111	242	624	470										
12.25 a. m.		4,905,290	55.0		2.5	1.1	281,890	23.0	17,124	43,124	240	619	510										
12.30 a. m.	300																						
12.45 a. m.		4,911,100	55.0		2.4	1.0		27.0	19,144	45,144	240	619	450	.6	7.0								
1.05 a. m.		4,916,820	54.0		2.4	1.0		23.0	21,163	47,163	240	619	440										
1.15 a. m.	300																						
1.25 a. m.		4,922,540	53.5		2.4	.9	283,590	29.0		49,182	242	624	430	.65	6.8								
1.45 a. m.		4,928,240	53.5		2.4	1.1		27.0		51,183	244	629	490										
2 a. m.	300																						
2.05 a. m.		4,934,030	53.5		2.4	.9		23.0		53,203	236	614	520	.55	6.5								
2.25 a. m.		4,939,960	53.0		2.4	.9	285,340	29.0		55,218	240	619	450										
2.45 a. m.	300	4,946,710	53.0	76.790	2.5	1.0		24.0		57,233	241	614	585	.7	7.5								
3.05 a. m.		4,951,700	52.5		2.4	.8		29.0		59,248	240	619	440										
3.25 a. m.		4,957,400	52.5		2.3	.5	286,900	23.0		61,250	240	619	560										
3.45 a. m. ^a	700	4,965,240	53.0		2.3	.1		32.0		63,230	240	389	510										
4.05 a. m.		4,970,740	53.5		2.4	.7		29.0		65,246	240	619	520	.7	8.0								

^a November 11.

^b Load down to about 400 amperes from 3.45 a. m. to 4.05 a. m.

Log of producer-gas test No. 9, Illinois No. 4 coal, November 10, 11, 1904—Continued.

Time.	(Coal consumed by producer (pounds).	Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motor.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Temperatures (° C.).		Gas calorimeter.				B. T. U.
		1.	2.	1.	2.	1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amps.	14	15	16	17	18	19	20	21	22	23	
4.15 a. m.	300									10	11							Outlet.	Inlet.	(cubic centimeters of water collected.	(cubic feet of gas.	As read.	Standardized.	
4.25 a. m.		4,976,640	53.0			2.4	1.0	288,720	28.0			241	619	440										
4.45 a. m.		4,982,180	53.5			2.5	.9		24.0			240	19	450										
5.05 a. m.	300	4,987,770	53.5			2.5	1.2		30.0			240	639	460	0.6	6.5								
5.25 a. m.		4,983,310	53.5			2.5	1.2	270,400	26.0			240	619	440										
5.45 a. m.	300	4,998,960	53.5			2.5	1.1		22.0			241	614	500	.6	6.4								
6.05 a. m.		5,004,630	53.5			2.5	1.6		26.0			240	614	490										
6.25 a. m.		5,010,140	53.5			2.5	1.5	272,120	23.0			241	629	495										
6.30 a. m.	300																							
6.45 a. m.		5,015,760	54.0	77,248		2.5	1.2		28.0			241	624	450	.6	6.4								
7.05 a. m.		5,021,300	54.0			2.5	1.0		22.0			239	624	515										
7.15 a. m.	300																							
7.25 a. m.		5,027,270	54.5			2.5	1.0	273,680	28.0			238	624	500	.7	8.0								
7.45 a. m.		5,033,160	55.0			2.5	.9		28.0			235	634	520										
8 a. m.	300																							
8.05 a. m.		5,039,840	56.0			2.4	.9		27.0			242	619	540										
8.25 a. m.		5,046,300	56.0			2.4	.4	275,540	27.0			240	619	490	.8	10.0								
8.45 a. m.		5,053,600	56.0	77,486		2.3	.1		26.0			241	619	570										
9.05 a. m.		5,060,000	57.0			2.4	.8		28.0			238	619	580										
9.25 a. m.		5,067,100	59.0			2.3	.6	277,280	27.5			234	614	600	.8	8.5								
9.30 a. m.	300																							
9.45 a. m.		5,074,200	62.0			2.3	.2		29.0			239	619	540										
10 a. m.	300																							
10.05 a. m.		5,081,340	64.0			2.3	.0		31.0			240	619	490										
10.25 a. m.		5,088,450	66.0			2.4	.8	279,180	30.0			240	619	540	.8	8.0								

a 8.05 a. m. to end of test, barometer 29.86.

PRODUCER-GAS TESTS.

1063

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.	B. T. U. standard- ized.
8.50 a. m. ^a	6.8	0.6	18.4	13.5	3.4	57.3	100.0	147.4	146.7
11 a. m.....	8.6	.0	16.6	11.3	4.7	58.8	100.0	147.3	147.2
12 m.....	8.6	.0	16.4	12.5	4.9	57.6	100.0	152.7	152.6
1 p. m.....	9.0	.0	16.4	12.3	5.2	57.1	100.0	166.4	166.4
2 p. m.....	8.8	.0	16.2	12.3	6.0	56.7	100.0	163.2	166.4
3 p. m.....	9.0	.2	15.6	9.3	7.4	58.5	100.0	165.6	165.5
4 p. m.....	8.8	.2	15.0	10.1	7.1	58.8	100.0	162.8	162.7
5 p. m.....	8.8	.0	15.4	8.1	7.8	59.9	100.0	165.5	164.8
6 p. m.....	9.0	.0	15.4	9.4	7.3	58.9	100.0	158.3	157.6
8 p. m.....	8.4	.8	15.6	10.4	7.3	57.5	100.0	168.2	167.3
9.15 p. m.....	8.0	.4	20.8	8.4	6.7	55.7	100.0	173.2	172.4
10 p. m.....	8.0	.2	20.0	12.0	4.5	55.3	100.0	159.4	158.1
11 p. m.....	8.8	.2	17.2	9.3	5.8	58.7	100.0	154.2	153.8
12 p. m.....	9.6	.2	15.6	7.8	7.8	59.0	100.0	174.7	172.8
1 a. m. ^b	9.8	.0	16.0	12.2	4.2	57.8	100.0	143.0	141.2
2 a. m.....	9.6	.0	15.0	9.3	6.2	59.9	100.0	150.5	148.8
3 a. m.....	10.0	.2	14.8	12.1	5.4	57.5	100.0	151.3	149.1
4 a. m.....	12.2	.0	9.2	5.7	5.7	67.2	100.0	112.7	110.4
5 a. m.....	11.0	.0	14.6	11.5	6.7	56.2	100.0	162.3	160.3
6 a. m.....	10.6	.0	14.8	12.6	4.8	57.2	100.0	147.0	145.0
7 a. m.....	10.0	.0	14.0	10.3	6.7	59.0	100.0	156.1	153.6
8 a. m.....	11.0	.0	11.8	6.8	6.2	64.2	100.0	130.9	129.0
9 a. m.....	11.2	.0	9.6	6.3	8.2	64.7	100.0	142.8	141.7
10 a. m.....	12.6	.0	6.2	2.0	9.9	69.3	100.0	138.0	139.3
11 a. m.....	11.2	.2	14.6	11.2	4.1	58.7	100.0	134.0	136.7
12 m.....	10.8	.0	16.2	13.0	4.1	55.9	100.0	145.0	146.7
1 p. m.....	11.0	.2	15.8	9.9	5.8	57.3	100.0	151.8	153.0
2 p. m.....	10.8	.0	16.0	10.0	4.1	59.1	100.0	134.3	134.8

^a November 10.

^b November 11.

Producer-gas test No. 9,^a Illinois No. 4 coal.

[Recorded by M. H. Mount and R. E. Peshak, November 10, 11, 1904.]

1. Duration of test, in hours	30
AVERAGE TEMPERATURE, °F.	
2. Gas leaving producer	882
3-6. (See footnote on p. 1027.)	

^a Gas-producer hopper leaked.

OPERATIONS OF THE COAL-TESTING PLANT.

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

7. Total steam used by producer	pounds..	7,800
8. Steam used by producer per hour	do....	260
9. Equivalent in pounds of coal per hour		48.2
10. Equivalent in pounds of dry coal per hour		42.2
11. Equivalent in pounds of combustible per hour		37.8
12. Average horsepower required to drive auxiliary machinery		9.3
13. Total water used in scrubber and tar extractor	cubic feet..	3,597
14. Cubic feet of water per hour per horsepower of producer plant		.48
15. Cubic feet of water per 1,000 cubic feet of gas produced		6.71

COAL CONSUMED IN PRODUCER.

16. Total coal consumed	pounds..	10,500
17. Moisture in coal	per cent..	12.43
18. Total dry coal consumed	pounds..	9,190
19. Refuse from dry coal	per cent..	10.53
20. Total refuse from coal	pounds..	968
21. Total combustible consumed	do....	8,222

COAL PER HOUR.

22. Coal consumed in producer	pounds..	350
23. Dry coal consumed in producer	do....	306.3
24. Combustible consumed in producer	do....	274.1
25. Equivalent coal used by producer plant	do....	398.2
26. Equivalent dry coal used by producer plant	do....	348.5
27. Equivalent combustible used by producer plant	do....	311.9

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired		9.10
29. Dry coal		7.96
30. Combustible		7.12

BRITISH THERMAL UNITS FROM COAL.

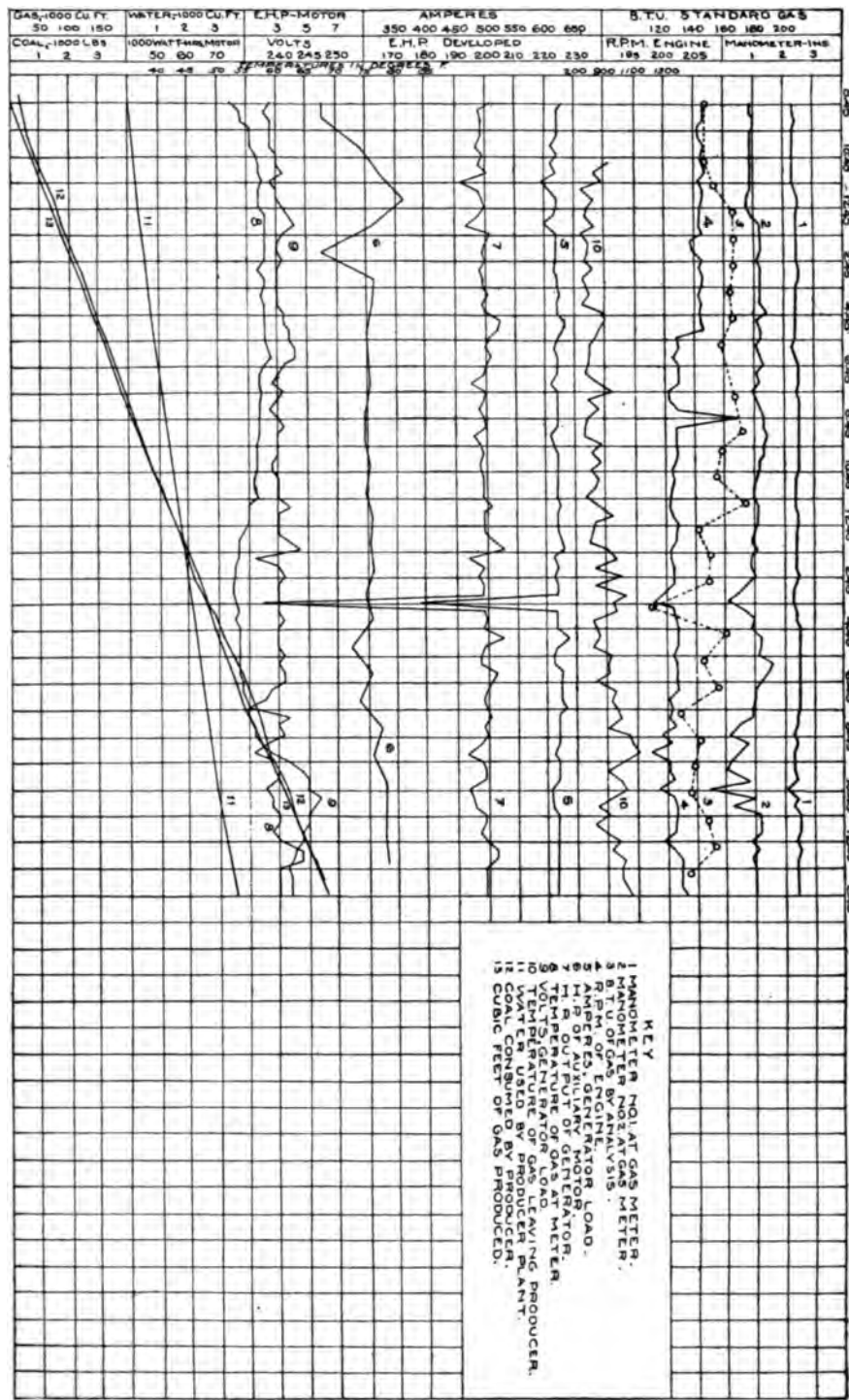
31. Per pound of coal as fired		11,237
32. Per pound of dry coal		12,834
33. Per pound of combustible		14,344
34. From coal as fired, per hour		3,930,000
35. From dry coal, per hour		3,930,000
36. From combustible, per hour		3,930,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total		536,435
38. Per hour		17,881
39. Per pound coal consumed in producer		51.1
40. Per pound dry coal consumed in producer		58.4
41. Per pound combustible consumed in producer		65.3
42. Per pound equivalent coal used by producer plant		44.9
43. Per pound equivalent dry coal used by producer plant		51.4
44. Per pound equivalent combustible used by producer plant		57.4

FIG. 114.—Graphic log sheet, producer-gas test, Illinois No. 4 coal.



OPERATIONS OF THE COAL-TESTING PLANT.

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot	151.5
46. Per pound dry coal burned in producer.....	8,840
47. Per hour per brake horsepower	11,620

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes	189.1
49. Electrical horsepower developed at switchboard.....	198.4
50. Brake horsepower available for outside purposes.....	223
51. Brake horsepower developed at engine	233

EFFICIENCIES.

52. Of conversion and cleaning gas.....	.690
53. Of producer plant.....	.603

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes	1.85	1.62	1.45
55. Pounds consumed in producer per electrical horsepower developed at switch board	1.76	1.55	1.38
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes	1.57	1.37	1.23
57. Pounds consumed in producer per brake horsepower ^a developed at engine	1.50	1.31	1.17
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	2.11	1.85	1.65
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	2.01	1.76	1.57
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes	1.79	1.56	1.40
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine	1.71	1.50	1.34

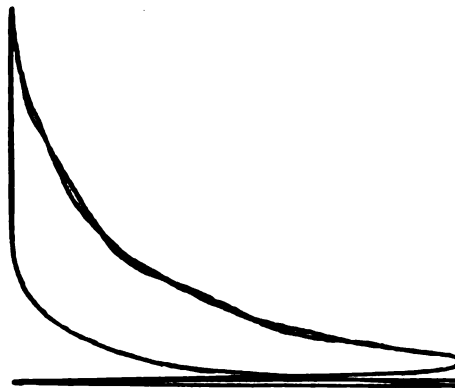
^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

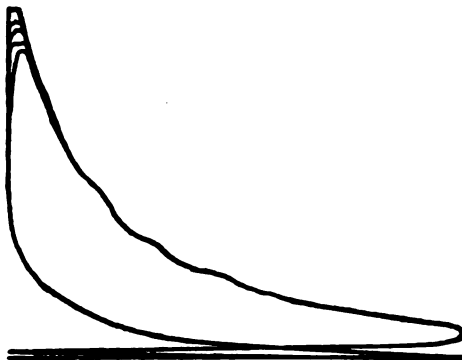
62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture	12.43	Carbon dioxide (CO ₂).....	9.72
Volatile matter	32.65	Oxygen (O ₂).....	.12
Fixed carbon	45.70	Carbon monoxide (CO).....	15.12
Ash	9.22	Hydrogen (H ₂).....	9.98
	100.00	Methane (CH ₄).....	6.00
Sulphur	1.41	Nitrogen (N ₂)	59.06
			100.00

GAS ENGINE.

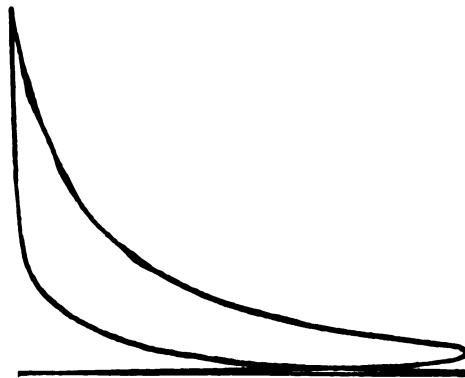
Although the load was reduced for twenty minutes from 3.45 a. m. to 4.05 a. m. November 11, this was disregarded in making up the report, as it was so brief a period out of the thirty hours. The report is based on the results of the full run from 8.45 a. m. November 10 to 2.45 p. m. November 11, thirty hours.



Right cylinder M. E. P., 54; Max., 280; Rel., 24; I. H. P., 87.54



Center cylinder. M. E. P., 54; Max., 280; Rel., 30; I. H. P., 87.45.



Left cylinder. M. E. P., 48; Max., 280; Rel., 24; I. H. P., 77.6.

Indicator diagrams taken November 10, 1904, during gas-engine test No. 9, on Illinois No. 4 coal. Scale of spring, 80; revolutions per minute, 205.7.

There was no difficulty, during the whole of the test of Illinois No. 4, in keeping the producer bed in good condition. The coal yielded 75 gallons of tar, and gave a rich, uniform gas, which left no trace of tar or sulphur in the engine valves. It may be placed among the grade of gas-producer coals.

Report of gas-engine test No. 9.

Recorded by R. W. Cummings and W. C. Weidmann, November 10, 11, 1904.

Producer test No. 9.

Coal: General number, Illinois No. 4; special number, G. P. 9. Car initials and number, St. L., T. and E. 1057.

Duration of test, in hours	30
Revolutions per minute (mean)	202.9
Explosions per minute (mean)	101.5
Cubic feet gas per hour, by meter	17,712
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure)	17,871
Maximum pressure:	
First cylinder	262.5
Second cylinder	265
Third cylinder	264.1
Pressure at release:	
First cylinder	26
Second cylinder	29.5
Third cylinder	24.5
Mean effective pressure:	
First cylinder	53.6
Second cylinder	56.14
Third cylinder	67.03
Indicated horsepower:	
First cylinder	85.52
Second cylinder	89.72
Third cylinder	81.79
Total indicated horsepower	257.03
Horsepower delivered (electrical horsepower)	198.4
Mechanical efficiency (engine and generator combined).....per cent..	77.2
Cubic feet standard gas per hour per indicated horsepower	69.55
Cubic feet standard gas per hour per electrical horsepower	90

INDIANA No. 1.

GENERAL RESULTS.

The general results of tests of Indiana No. 1 coal are shown in the following tables:

Log of producer-gas test No. 14, Indiana No. 1 coal, December 2, 3, 1904.

[Coal from Mildred mine of the J. Woolley Coal Company, Mildred, Ind.]

Time.	Coal consumed by producer (pounds).	(Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Gas calorimeter.					B. T. U.				
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercury).	Gas leaving (inches water).	(Gas.	Inlet.	Water.	Outlet.	Cubic centimeters of water collected.			Cubic feet of gas.	As read.	Standardized.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23			
9 a. m.	300	7,166,300	59.0	125,905	2.2	- 0.4	541,910		56,235		240	524	450	0.45	6.0		14.0	8.3	15.9	850	0.2	128.2	128.4		
9.20 a. m.		7,172,500	53.0		2.3	- .4			58,233		238	644	490				14.0	8.2	16.0	820	.2	137.7	138.9		
9.25 a. m.																	14.0	8.2	16.0	820	.2	137.7	138.9		
9.40 a. m.		7,178,780	56.5		2.3	- .4			60,258		242	634	500	.5	6.0	14.0	8.2	15.2	1,080	.2	140.8	141.2			
9.45 a. m.	300																								
10 a. m.		7,184,900	59.5		2.2	- .3			62,282		240	629	490			14.8	8.2	15.35	1,000	.2	121.8	122.6			
10.20 a. m.		7,191,000	61.0		2.2	- .4			64,297		240	629	520			15.8	8.4	15.0	1,020	.2	135.3	135.5			
10.30 a. m.	300																								
10.40 a. m.		7,197,390	62.0		2.3	- .3			66,318		240	624	485	.45	6.0	16.0	8.3	15.2	1,020	.2	138.8	138.9			
11 a. m.		7,203,660	63.0	126,245	2.3	- .3			68,338		239	624	490			16.8	8.4	15.3	1,090	.2	149.1	149.4			
11.15 a. m.	300																								
11.20 a. m.		7,209,900	64.5		2.4	- .0			70,362		241	629	475	.45	5.5	16.5	8.4	15.15	1,100	.2	147.2	147.5			
11.40 a. m.		7,215,750	64.5		2.4	+ .1			72,386		241	624	495			17.7	8.4	14.9	1,100	.2	141.6	143.3			
12 m.	300	7,221,500	64.5		2.3	- .0	548,880		74,404		240	624	490	.5	6.0	17.5	8.4	14.6	1,170	.2	138.8	140.8			
12.20 p. m.		7,227,460	64.5		2.3	- .0			76,426		240	624	510			17.0	8.4	14.5	1,140	.2	137.7	139.7			
12.40 p. m.		7,233,450	64.5		2.3	- .1			78,446		240	634	520	.55	7.0	17.2	8.5	15.4	1,150	.2	152.8	155.0			
12.45 p. m.	300																								
1 p. m.		7,239,300	65.0	126,580	2.3	- .0	551,000		80,466		240	634	500			17.6	8.5	15.6	1,120	.2	157.5	159.9			
1.20 p. m.		7,245,300	64.0		2.3	- .0			82,485		240	634	500												
1.30 p. m.	300																								
1.40 p. m.		7,251,150	64.0		2.3	- .0			84,502		241	619	500	.4	5.5	17.8	8.5	15.3	1,170	.2	157.5	160.0			
2 p. m.		7,256,890	64.0		2.3	+ .2	553,060		86,522		241	614	500			18.0	8.5	15.2	1,120	.2	150.7	153.3			
2.15 p. m.	300																								
2.20 p. m.		7,262,590	64.0		2.3	+ .2			88,536		241	634	460			17.5	8.4	15.2	1,170	.2	157.5	159.8			

a December 2, 9 a. m. to 5 p. m., barometer 29.48 inches.

Log of producer-gas test No. 14, Indiana No. 1 coal, December 2, 3, 1904—Continued.

Time.	(Coal consumed by producer (pounds).	Temperature of gas (° F.).			Water meter (cubic feet).			Manometers at gas meter (inches water).			Auxiliary motors.			Speed counters on gas engine.			Load.			Temperature of gas leaving producer (° C.).			Manometers at producer.			Temperatures (° C.).			Gas calorimeter.			B. T. U.		
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33		
		Gas meter (cubic feet).	Water meter (cubic feet).	1.	2.	1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amps.	Temp. entering (inches mer- cury).	Gas leaving (inches wa- ter).	Gas.	Water.	Inlet.	Outlet.	(Cubic centimeters of water collected).	Cubic feet of gas.	As read.	Standardized.											
2.40 p. m.	300	7,268,240	64.0	2.4	0.3	90,555	241	624	490	0.4	5.5	17.5	8.4	15.0	1,240	0.2	162.3	164.6	162.3	164.6														
3 p. m.	300	7,273,890	64.0	2.4	0.3	92,574	241	624	490	0.4	5.5	17.5	8.4	14.8	1,200	0.2	160.3	162.8	160.3	162.8														
3.20 p. m.	300	7,279,500	64.0	2.3	0.3	94,597	240	619	500	0.4	5.5	17.5	8.4	14.6	1,200	0.2	147.6	149.8	147.6	149.8														
3.40 p. m.	300	7,285,210	64.0	2.4	0.1	96,610	241	624	500	0.4	5.5	17.0	8.4	14.3	1,210	0.2	141.3	144.7	141.3	144.7														
3.45 p. m.	300	7,290,960	64.0	2.4	0.0	98,625	241	624	490	0.4	5.5	17.0	8.4	15.1	1,210	0.2	160.7	163.2	160.7	163.2														
4 p. m.	300	7,296,830	64.0	2.5	0.0	640	240	624	540	0.4	5.5	17.5	8.5	14.9	1,200	0.2	152.4	154.6	152.4	154.6														
4.30 p. m.	300	7,303,680	64.0	2.5	0.0	2,664	242	624	490	0.4	5.5	17.5	8.4	15.0	1,210	0.2	158.3	160.7	158.3	160.7														
4.40 p. m.	300	7,308,400	64.0	2.5	0.0	4,686	241	619	510	0.6	7.0	17.8	8.5	14.9	1,240	0.2	155.9	159.9	155.9	159.9														
5 p. m.	300	7,314,140	64.0	2.5	0.2	6,707	242	639	490	0.4	5.5	17.5	8.5	14.9	1,240	0.2	142.5	146.2	142.5	146.2														
5.20 p. m.	300	7,319,690	64.0	2.5	0.2	8,739	242	624	470	0.4	5.5	17.5	8.5	14.9	1,280	0.2	162.2	164.7	162.2	164.7														
5.40 p. m.	300	7,325,190	64.0	2.5	0.2	10,768	244	624	490	0.6	6.5	17.5	8.5	15.2	1,300	0.2	172.6	176.2	172.6	176.2														
6 p. m.	300	7,330,660	64.0	2.5	0.2	12,795	244	624	500	0.6	6.5	17.0	8.6	15.0	1,250	0.2	158.6	159.9	158.6	159.9														
6.20 p. m.	300	7,335,970	64.5	2.5	0.2	14,828	239	619	500	0.6	6.5	16.5	8.5	14.7	1,250	0.2	153.6	155.8	153.6	155.8														
6.40 p. m.	300	7,341,220	65.0	2.5	0.3	16,860	240	624	460	0.4	5.0	17.0	8.5	14.8	1,280	0.2	157.1	159.3	157.1	159.3														
7 p. m.	300	7,346,570	65.5	2.5	0.3	18,900	240	624	500	0.4	5.5	17.0	8.6	14.2	1,190	0.2	132.1	135.4	132.1	135.4														
7.20 p. m.	300	7,352,100	65.0	2.4	0.2	20,939	241	624	490	0.45	5.5	16.9	8.6	15.5	1,150	0.2	137.1	139.6	137.1	139.6														
7.40 p. m.	300	7,357,500	65.0	2.5	0.1	566,590	240	624	490	0.4	5.5	16.5	8.5	15.7	1,160	0.2	165.5	167.5	165.5	167.5														
8 p. m.	300	7,362,850	65.0	2.4	0.2	24,970	239	624	520	0.4	5.5	16.5	8.4	15.25	1,140	0.2	156.7	158.6	156.7	158.6														
8.20 p. m.	300	7,368,520	65.0	2.5	0.0	26,991	240	624	530	0.4	5.5	16.5	8.5	14.8	1,280	0.2	162.4	164.3	162.4	164.3														
8.40 p. m.	300	7,374,260	65.0	2.4	0.0	568,705	240	624	540	0.6	6.5	16.5	8.5	14.8	1,280	0.2	162.4	164.3	162.4	164.3														
8.45 p. m.	300	7,374,260	65.0	2.4	0.0	568,705	240	624	540	0.6	6.5	16.5	8.5	14.8	1,280	0.2	162.4	164.3	162.4	164.3														
9 p. m.	300	7,374,260	65.0	2.4	0.0	568,705	240	624	540	0.6	6.5	16.5	8.5	14.8	1,280	0.2	162.4	164.3	162.4	164.3														

a 5 p. m. to end of test, barometer 29.76 inches.

Log of producer-gas test No. 14, Indiana No. 1 coal, December 2, 3, 1914—(continued.)

Time.	(Coal consumed by producer (pounds).)			Temperature of gas (° F.).			Water meter (cubic feet).			Manometers at gas meter (inches water).			Auxiliary meters on gas engine.			Load.			Temperature of gas leaving producer (° C.).			Manometers at producer.			Temperatures (° C.).			Gas calorimeter.			B. T. U.						
Gas meter (cubic feet).			Temperature of gas (° F.).			Water meter (cubic feet).			Manometers at gas meter (inches water).			Auxiliary meters on gas engine.			Load.			Temperature of gas leaving producer (° C.).			Manometers at producer.			Temperatures (° C.).			Gas calorimeter.			B. T. U.							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Water.			Cubic centimeters of water collected.			Cubic feet of gas.			As read.			Standardized.		
Gas meter (cubic feet).			Temperature of gas (° F.).			Water meter (cubic feet).			Manometers at gas meter (inches water).			Auxiliary meters on gas engine.			Load.			Temperature of gas leaving producer (° C.).			Manometers at producer.			Temperatures (° C.).			Gas calorimeter.			B. T. U.							
Gas meter (cubic feet).			Temperature of gas (° F.).			Water meter (cubic feet).			Manometers at gas meter (inches water).			Auxiliary meters on gas engine.			Load.			Temperature of gas leaving producer (° C.).			Manometers at producer.			Temperatures (° C.).			Gas calorimeter.			B. T. U.							
Gas meter (cubic feet).			Temperature of gas (° F.).			Water meter (cubic feet).			Manometers at gas meter (inches water).			Auxiliary meters on gas engine.			Load.			Temperature of gas leaving producer (° C.).			Manometers at producer.			Temperatures (° C.).			Gas calorimeter.			B. T. U.							

^a December 3.
^b 8.15 a. m. Through negligence the gas holder was allowed to drop to such a point that it was necessary to throw the load off for a few minutes, after which part load was carried until 3.45, when full load was again put on.

Log of producer-gas test No. 14, Indiana No. 1 coal, December 2, 3, 1904—Continued.

Time.	(Coal consumed by producer (pounds).	3	4	5	Water meter (cubic feet).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometer at producer.	Temperatures (° C.).				Gas calorimeter.		B. T. U.	
					Temperature of gas (° F.).		Manometer at gas meter (inches water).		Speed counters on gas engine.		Load.				Temperatures (° C.).		Inlet.	Outlet.	(cubic centimeters of water collected).	(cubic feet of gas).		
					1	2	1	2	1	2	Volts.	Amperes.			1	2						17	18	19	20	21	22	23
3.40 a. m.		7,486,770	61.0		2.0	1.1			69,486		240	414	680	0.7	7.0	14.0	10.2	14.5	1,400	0.2	119.2	119.4
3.45 a. m.	340																					
4 a. m.		7,492,930	60.5		2.1	.2	583,940		71,512		244	624	570			14.5	8.4	14.5	1,350	.2	155.5	155.7
4.20 a. m.		7,499,030	61.5		2.3	.2			73,389		242	624	600	.6	6.0	14.3	8.1	13.2	1,400	.2	141.7	142.2
4.30 a. m.	340																					
4.40 a. m.		7,505,580	61.0		2.2	.5			75,570		242	624				14.0	8.1	12.9	1,400	.2	133.3	133.7
5 a. m.		7,511,730	61.0	129,624	2.2	.5	585,800		77,585		241	624		.5	5.0	14.0	8.1	12.8	1,400	.2	130.5	130.8
5.15 a. m.	340																					
5.20 a. m.		7,518,350	61.0		2.3	.6			79,590		241	624				14.8	8.2	12.5	1,400	.2	119.4	(a)
5.40 a. m.		7,524,560	61.0		2.3	.3			81,000		240	624				14.8	8.2	12.5	1,400	.2	119.4	
6 a. m.	340				2.3	.6	588,160		83,005		241	624				14.0	8.1	12.4	1,400	.2	119.4	
6.20 a. m.		7,537,700	61.0		2.3	.3			85,028		242	624				14.0	8.1	12.4	1,400	.2	119.4	
6.40 a. m.		7,543,840	61.5		2.3	.3			87,648		242	624				14.5	8.1	12.2	1,450	.2	117.8	
6.45 a. m.	340																					
7 a. m.		7,549,900	61.0		2.3	.3	590,230		89,669		242	619		.5	6.5	14.5	8.2	12.2	1,350	.2	107.1	
7.20 a. m.		7,555,980	61.0		2.3	.4			91,689		242	619	600			14.6	8.1	11.7	1,450	.2	103.6	
7.30 a. m.	340																					
7.40 a. m.		7,562,110	61.0		2.3	.3			93,708		240	624				14.8	8.0	13.4	1,450	.2	155.1	156.1
8 a. m.		7,568,150	61.0		2.3	.3	592,270		95,740		240	624				14.9	8.1	13.3	1,500	.2	154.8	155.8
8.15 a. m.	340																					
8.20 a. m.		7,574,200	61.0		2.3	.1			97,784		241	624	560			15.0	8.1	13.5	1,400	.2	150.0	151.0
8.40 a. m.		7,580,180	61.0		2.3	.3			99,830		241	624	590			15.0	8.2	13.9	1,450	.2	163.9	164.8
9 a. m.	340			130,510	2.4	.0	594,290		1,451		240	634	500	.55	6.0	15.0	8.1	13.1	1,500	.2	148.8	149.2
9.20 a. m.		7,591,500	63.0		2.4	+ .2			3,878		239	624	570			15.0	8.0	13.4	1,500	.2	160.7	160.9
9.40 a. m.		7,597,620	62.5		2.4	.3			5,902		238	624	590			15.0	8.0	13.2	1,500	.2	154.8	155.2
9.45 a. m.	340																					

a From 5.20 a. m. to 7.20 a. m., inclusive, the meter connected with the calorimeter was out of order.

Log of producer-gas test No. 14, Indiana No. 1 coal, December 2, 3, 1904—Continued.

Time.	(Coal consumed by producer (pounds).	Gas calorimeter.																									
		Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Temperatures (° C.).				Cubic centimeters of water collected.		Cubic feet of gas.		B. T. U.	
																		Gas.									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23			
		(gas meter (cubic feet).				1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amps.		Air entering (inches mer- cury).	Gas leaving (inches wa- ter).		Inlet.	Outlet.			As read.	Standardized.				
10 a. m.		7,603,650	63.0		2.4	0.2	596,400		7,926			240	624	400	0.65	6.5	16.0	8.0	13.4	1,500	0.2	161.7	163.3				
10.20 a. m.		7,609,680	63.5		2.4	.2			9,951			240	624	405			16.5	8.0	13.6	1,500	.2	166.3	168.8				
10.30 a. m.	300																										
10.40 a. m.		7,615,750	63.5		2.4	.2	598,450		11,976			240	624	450	.55	5.0	18.3	8.0	13.9	1,450	.2	169.8	172.8				
11 a. m.		7,621,700	64.5	130,985	2.3	.2			13,998			240	619	550			18.0	8.0	13.8	1,450	.2	166.6	169.4				
11.15 a. m.	300																										
11.20 a. m.		7,627,700	65.0		2.3	.0			16,020			240	624	520	.5	5.5	18.3	8.0	14.1	1,450	.2	175.4	178.6				
11.40 a. m.		7,633,500	66.0		2.3	.1			18,045			240	624	540			19.8	8.2	14.3	1,450	.2	175.4	179.5				
12 m.	300	7,639,600	66.0		2.3	.1	600,630		20,068			240	624	580			20.0	8.1	14.2	1,450	.2	175.4	179.5				
12.20 p. m.		7,645,500	66.0		2.3	.2			22,086			238	619	620	.5	4.5	20.0	8.2	14.1	1,450	.2	169.8	173.8				
12.40 p. m.		7,651,750	66.5		2.3	.3			24,104			238	624				20.0	8.2	14.2	1,400	.2	166.6	170.5				
12.45 p. m.	300																										
1 p. m.		7,657,810	66.5	131,367	2.3	.3	602,830		26,125			238	624	560	.8	5.5	20.0	8.2	14.2	1,450	.2	172.6	176.8				
1.20 p. m.		7,664,300	66.5		2.3	.5			28,142			239	619	600			20.5	8.2	14.1	1,350	.2	155.1	159.0				
1.30 p. m.	300																										
1.40 p. m.		7,671,100	66.5		2.2	.6			30,156			240	619	590			20.0	8.2	14.2	1,450	.2	172.6	176.7				
2 p. m.		7,677,800	66.5		2.2	.8	604,900		32,172			240	634	560	.85	7.0											
2.15 p. m.	300																										
2.20 p. m.		7,684,200	66.5		2.2	.5			34,188			244	624	570			18.7	8.3	14.5	1,350	.2	165.8	168.9				
2.40 p. m.		7,690,710	66.5		2.1	.9			36,195			238	619	640			18.5	8.2	14.2	1,300	.2	154.8	157.8				
3 p. m.		7,697,800	66.6	131,790	2.0	1.5	607,000		38,190			233	595	570			18.5	8.3	12.3	1,350	.2	107.0	108.8				

PRODUCER-GAS TESTS.

OPERATIONS OF THE COAL-TESTING PLANT.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
9.15 a. m. ^a	7.6	0.8	16.4	11.0	3.4	60.8	100.0	131.8
12.15 p. m.....	8.6	0.2	14.0	9.1	5.5	62.6	100.0	139.1
2.15 p. m.....	9.2	0.4	15.6	11.1	6.0	57.7	100.0	156.9
4.15 p. m.....	9.2	0.4	15.6	11.4	6.0	57.4	100.0	158.0
6.15 p. m.....	8.4	0.8	14.2	9.0	5.8	61.8	100.0	142.7
8.15 p. m.....	9.6	0.2	15.0	6.6	7.2	61.4	100.0	152.0
10.15 p. m.....	9.4	0.0	16.2	9.5	5.9	59.0	100.0	152.5
12.15 a. m. ^b	9.0	0.0	18.4	10.5	6.4	55.7	100.0	168.9
2.15 a. m.....	9.4	0.2	16.4	1.8	7.2	65.0	100.0	140.2
4.15 a. m.....	11.0	0.2	12.2	9.8	4.9	61.9	100.0	128.9
6.15 a. m.....	10.6	0.0	13.6	10.6	5.5	59.7	100.0	142.9
8.15 a. m.....	12.8	0.4	14.0	9.0	6.0	57.8	100.0	144.1
10.15 a. m.....	9.6	0.2	11.8	7.5	6.9	64.0	100.0	140.8
12.15 p. m. ^c	10.8	0.0	10.6	6.6	7.5	64.5	100.0	139.8
2.15 p. m.....	11.2	0.2	8.6	10.6	6.9	62.5	100.0	140.4

^a December 2.^b December 3.^c 11.15 a. m. Gas sample lost. Next sample drawn at 12.15 p. m.*Producer-gas test No. 14,^a Indiana No. 1 coal.*

[Recorded by W. C. Weldmann and Kurt Toensfeldt, December 2-3, 1904.]

1. Duration of test, in hours 29.67

AVERAGE TEMPERATURE, ° F.

2. Gas leaving producer 975

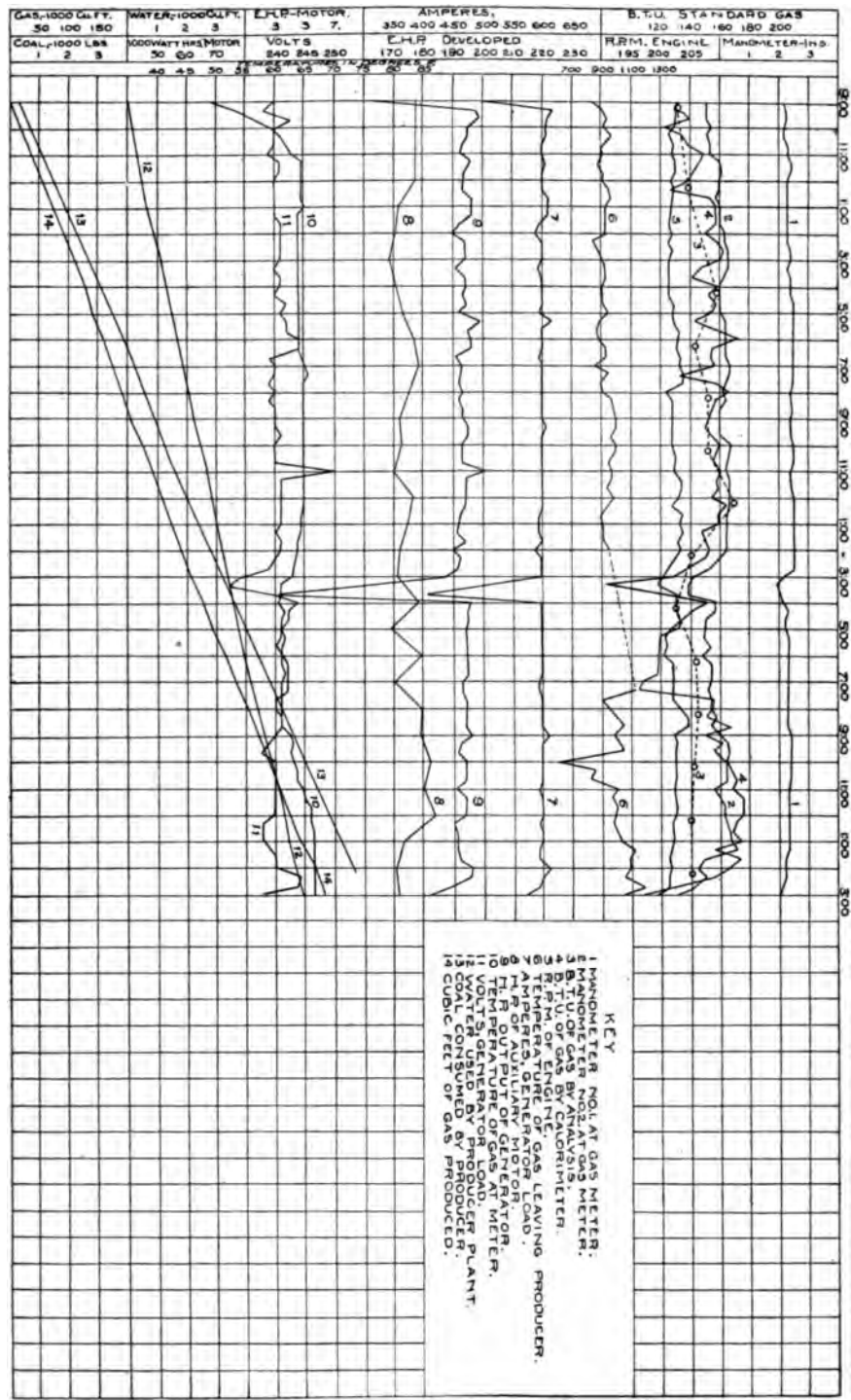
3-6. (See footnote on page 1027).

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

7. Total steam used by producer pounds.. 6,970
8. Steam used by producer per hour do..... 235
9. Equivalent in pounds of coal per hour 40.1
10. Equivalent in pounds of dry coal per hour..... 35.5
11. Equivalent in pounds of combustible per hour..... 31.5
12. Average horsepower required to drive auxiliary machinery 11.6
13. Total water used in scrubber and tar extractor cubic feet.. 5,828
14. Cubic feet of water per hour per horsepower of producer plant 79
15. Cubic feet of water per 1,000 cubic feet of gas produced..... 11.20

^a Gas-producer hopper leaked.

FIG. 115.—Graphic log sheet, producer-gas test, Indiana No. 1 coal.



OPERATIONS OF THE COAL-TESTING PLANT.

COAL CONSUMED IN PRODUCER.

16. Total coal consumed	pounds..	11,700
17. Moisture in coal	per cent..	11.51
18. Total dry coal consumed	pounds..	11,360
19. Refuse from coal	per cent..	11.33
20. Total refuse from dry coal	pounds..	1,180
21. Total combustible consumed	do....	9,180

COAL PER HOUR.

22. Coal consumed in producer	pounds..	394.5
23. Dry coal consumed in producer	do....	349.3
24. Combustible consumed in producer	do....	309.5
25. Equivalent coal used by producer plant	do ...	434.6
26. Equivalent dry coal used by producer plant	do....	384.8
27. Equivalent combustible used by producer plant	do....	341

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired	10.30
29. Dry coal	9.10
30. Combustible	8.05

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired	11,534
32. Per pound of dry coal	13,037
33. Per pound of combustible	14,720
34. From coal as fired, per hour	4,553,000
35. From dry coal, per hour	4,553,000
36. From combustible, per hour	4,553,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total	521,100
38. Per hour	17,560
39. Per pound coal consumed in producer	44.5
40. Per pound dry coal consumed in producer	50.3
41. Per pound combustible consumed in producer	56.7
42. Per pound equivalent coal used by producer plant	40.4
43. Per pound equivalent dry coal used by producer plant	45.6
44. Per pound equivalent combustible used by producer plant	51.5

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot	153.7
46. Per pound dry coal burned in producer	7,730
47. Per hour per brake horsepower	11,480

PRODUCER-GAS TESTS.

1077

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	188.3
49. Electrical horsepower developed at switch board.....	199.9
50. Brake horsepower available for outside purposes.....	221.5
51. Brake horsepower developed at engine.....	235

EFFICIENCIES.

52. Of conversion and cleaning gas.....	.593
53. Of producer plant.....	.535

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	2.10	1.86	1.64
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	1.97	1.75	1.55
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	1.78	1.58	1.40
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	1.68	1.49	1.32
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	2.31	2.04	1.81
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	2.17	1.93	1.71
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	1.96	1.74	1.54
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	1.85	1.64	1.45

^a Based on an assumed efficiency of 85 per cent for generator and belt.

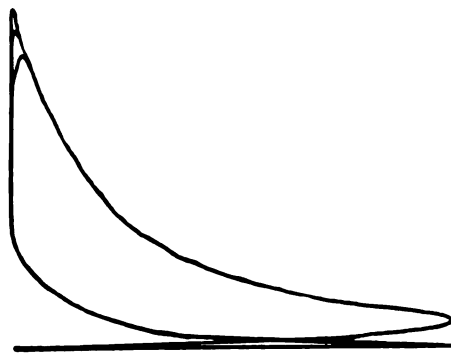
AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	11.51	Carbon dioxide (CO ₂).....	9.89
Volatile matter.....	36.04	Oxygen (O ₂).....	.25
Fixed carbon.....	42.37	Carbon monoxide (CO).....	14.10
Ash.....	10.08	Hydrogen (H ₂).....	9.56
	100.00	Methane (CH ₄).....	6.08
Sulphur.....	2.61	Nitrogen (N ₂).....	60.12
			100.00

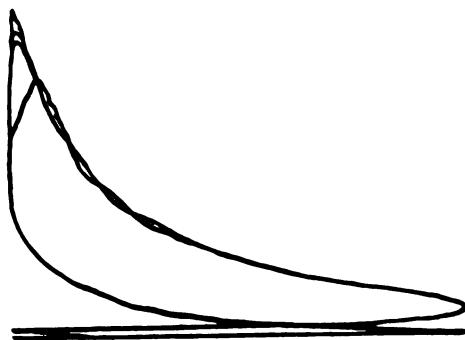
GAS ENGINE.

After a run of twenty minutes on part load, the engine was brought up to its normal capacity, and, with the single exception of a reduction in load for a few minutes, due to the carelessness of the man on night duty at the producer, the test was carried through without interruption.

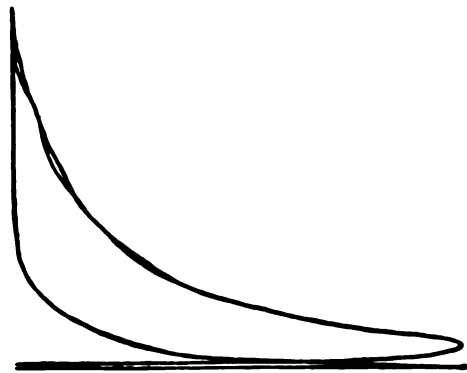
The gas from this coal was of uniformly good quality. No trouble was experienced in working the bed, and the coal may be considered an excellent producer fuel. It yielded about 70 gallons of black tar.



Right cylinder. M. E. P., 50; Max., 200; Rel., 30; I. H. P., 94.8.



Center cylinder. M. E. P., 50; Max., 200; Rel., 30; I. H. P., 90.3.



Left cylinder. M. E. P., 51; Max., 200; Rel., 30; I. H. P., 91.9.

Indicator diagrams taken December 2, 1904, during gas-engine test No. 14, on Indiana No. 1 coal. Revolutions per minute, 24.

PRODUCER-GAS TESTS.

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Report of gas-engine test No. 14.

Recorded by R. W. Cummings and W. C. Weidmann, December 2, 1903.

Producer test No. 14.

Coal: General number, Indiana No. 1; special number, G. P. 14. Car initials and number, E. and T. H. 5274.

Duration of test, in hours.....	29½
Revolutions per minute (mean).....	202.2
Explosions per minute (mean).....	101.1
Cubic feet gas per hour, by meter	17,710
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	17,550
Maximum pressure:	
First cylinder.....	255.8
Second cylinder.....	234.9
Third cylinder.....	252.26
Pressure at release:	
First cylinder.....	29.33
Second cylinder.....	30.33
Third cylinder.....	27.73
Mean effective pressure:	
First cylinder.....	58.6
Second cylinder.....	58.06
Third cylinder.....	53.73
Indicated horsepower:	
First cylinder.....	92.32
Second cylinder.....	92.52
Third cylinder.....	85.66
Total indicated horsepower.....	270.50
Horsepower delivered (electrical horsepower)	199.9
Mechanical efficiency (engine and generator combined).....per cent..	73.9
Cubic feet standard gas per hour per indicated horsepower.....	64.9
Cubic feet standard gas per hour per electrical horsepower.....	87.8

INDIANA No. 2.

GENERAL RESULTS.

The following tables show the general results of gas-producer test 13, Indiana No. 2 coal:

Log of producer-gas test No. 13, Indiana No. 2 coal, November 28, 29, 1904.

[Coal from Electric mine of the T. D. Seales Coal Company, Boonville, Ind.]

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Gas calorimeter.						B. T. U.			
																				Temperatures (° C.).									
																				Gas.		Water.		Cubic centimeters of water collected.				Cubic feet of gas.	
1.	2.	1.	2.	1.	2.	1.	2.	1.	2.	1.	2.	1.	2.	12	13	14	15	16	17	18	19	20	21	22	23				
9.30 a. m.	300																												
9.45 a. m.		2.3	0.4	484,060		73,118		240	6419								0.4	6.0	12.0	8.9	13.80		1,270	0.2	124.4	125.1			
9.50 a. m.																			12.0	8.9	14.00		1,150	.2	116.3	116.8			
9.55 a. m.																			14.3	9.1	14.50		1,120	.2	119.7	119.8			
10 a. m.	300																												
10.05 a. m.		2.4	.8			75,154		242	414	500									16.0	9.2	15.90		1,050	.2	139.2	140.3			
10.15 a. m.																													
10.25 a. m.		2.4	.8			77,167		241	450	480									16.0	9.3	15.60		1,100	.2	137.2	139.7			
10.35 a. m.																													
10.45 a. m.	300	2.5	1.0	485,980		79,185		242	424	460	.4	6.0							17.5	9.4	15.60		1,280	.2	151.2	154.8			
10.55 a. m.																													
11.05 a. m.		2.3	— .1			81,204		238	614	590									20.0	9.4	15.00		1,400	.2	155.5	160.8			
11.15 a. m.	300																		21.5	9.6	14.90		1,400	.2	147.2	153.3			
11.20 a. m.																													
11.25 a. m.		2.0	— .9			88,193													22.5	9.6	15.00		1,400	.2	130.1	135.3			
11.30 a. m.																													
11.45 a. m.	300	2.4	.4	488,000		85,204		240	623	580									22.0	9.7	16.40		1,150	.2	144.8	150.4			
11.50 a. m.																													
12 m.																													
12.05 p. m.																			22.0	9.8	16.50		1,170	.2	157.1	163.1			
12.15 p. m.	300																												
12.25 p. m.																													
12.30 p. m.		2.4	.4			89,231		234	513	560									21.8	9.7	15.20		1,400	.2	152.8	158.8			

^a November 28. Average barometer for test 29.25 inches.
^b Test started on about 400 amperes. At 11 a. m. load was raised to about 600 amperes, but had to be reduced at 11.25 to about 500. The test was continued on this load until 8.45 a. m. November 29, when full load was again put on and easily carried through the remainder of the run.

Log of producer-gas test No. 13, Indiana No. 2 coal, November 28, 29, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Gas calorimeter.				B. T. U.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
12.35 p. m.																	22.0	9.8	15.05	1,400	0.2	145.6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																

Log of producer-gas test No. 13, Indiana No. 2 coal, November 28, 29, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Auxiliary motor.				Speed counters on gas engine.		Load.	Gas calorimeter.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
		Manometers at gas meter (inches water).		Watt meter.		Ammeter.			1.		2.		Temperatures of gas leaving producer (°C.).	Manometers at producer.		Temperatures (°C.).		Gas calorimeter.		B. T. U.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
		Temperature of gas (° F.).	Water meter (cubic feet).	1.	2.	1.	2.		Volts.	Amperes.	Gas.	Inlet.		Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
																			3.		4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
8.55 p. m.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											

November 29.

PRODUCER-GAS TESTS.

Log of producer-gas test No. 15, Indiana No. 2 coal, November 28, 29, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Manometers at producer (inches mercury).		Gas calorimeter.						B. T. U.	
		3	4			1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	Air entering (inches mercury).	Gas leaving water-meter).	Gas.	Temperatures (° C.).		Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.	
																	Inlet.	Outlet.					
1.15 a. m.	300											12	13	14	15	16	17	18	19	20	21	22	23
1.25 a. m.		6,924,820	70.0	2.5	0.7					68,115		240	518	400			21.0	9.7	17.30	850	0.2	128.2	132.7
1.35 a. m.																							
1.45 a. m.		6,929,650	70.0	2.5	.7	513,500				70,138		240	508	450	0.6	5.5	21.0	9.7	17.30	850	.2	128.2	132.8
1.55 a. m.																							
2.05 a. m.		6,934,440	70.0	2.5	.7					72,160		238	518	420			21.0	9.7	17.10	850	.2	125.0	129.4
2.15 a. m.	300																						
2.25 a. m.		6,939,830	69.5	2.5	.7					74,172		240	518	400			21.0	9.7	16.80	850	.2	119.8	124.2
2.35 a. m.																							
2.45 a. m.		6,944,100	69.0	2.5	.7	515,280				76,191		240	518	440	.3	4.0	21.0	9.7	16.80	850	.2	119.8	124.2
2.55 a. m.																							
3.05 a. m.		6,949,000	69.0	2.5	.7					78,214		240	513	480			20.5	9.8	16.40	800	.2	104.7	108.2
3.15 a. m.																							
3.25 a. m.		6,954,130	70.0	2.5	.7					80,226		240	518	500			20.5	9.6	15.60	800	.2	95.2	100.7
3.30 a. m.	300																						
3.35 a. m.																							
3.45 a. m.		6,959,360	70.0	2.5	.7	517,170				82,232		240	518	430	.7	6.0	20.0	9.7	14.90	850	.2	87.7	90.6
3.55 a. m.																							
4.05 a. m.		6,964,600	70.0	2.5	.5					84,247		240	518	450			20.0	9.7	17.70	850	.2	134.9	139.3
4.15 a. m.																							
4.25 a. m.		6,969,650	70.0	2.5	.6					86,260		240	513	480			20.0	9.8	18.70	850	.2	150.4	155.3
4.30 a. m.	300																						
4.35 a. m.																							
4.45 a. m.		6,974,610	70.0	2.6	.6	519,010				88,273		240	513				20.0	9.8	18.80	850	.2	151.9	156.8
4.55 a. m.																							
5.05 a. m.		6,979,510	70.0	2.5	1.0					90,286		241	518				20.0	9.8	19.60	850	.2	165.1	170.6
5.15 a. m.	300																20.0	9.6	18.60	850	.2	151.9	156.8

Log of producer-gas test No. 15, Indiana No. 2 coal, November 28, 29, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Temperatures (° C.).				Gas calorimeter.		B. T. U.			
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercur.).	Gas leaving (inches wa-ter).	Gas.	Inlet.	Outlet.	Water.	Cubic centimeters of water collected.	Cubic feet of gas.			As read.	Standardized.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23			
5.25 a. m.		6,984,360	69.0		2.5	0.8			92,300		240	518													
5.35 a. m.																									
5.45 a. m.		6,989,280	69.0	119,421	2.5	.8	520,800		94,307		240	518													
5.55 a. m.																									
6.05 a. m.		6,994,280	69.0		2.5	1.0			96,311		241	518													
6.15 a. m.	300																								
6.25 a. m.		6,999,800	69.0		2.5	.8			98,316		240	528													
6.35 a. m.																									
6.45 a. m.		7,004,300	69.0		2.5	1.0	522,510		322		240	518													
6.55 a. m.																									
7.05 a. m.		7,009,310	69.0		2.5	1.0			2,328		240	518													
7.15 a. m.	300																								
7.25 a. m.		7,014,460	69.0		2.5	1.0			4,339		240	518													
7.35 a. m.																									
7.45 a. m.		7,019,310	69.0	119,702	2.5	1.0	524,320		6,350		240	518	460												
7.55 a. m.																									
8.05 a. m.		7,024,360	70.0		2.5	1.0			8,368		236	518	500												
8.15 a. m.	300																								
8.25 a. m.		7,029,480	72.0		2.5	1.0			10,408		240	528													
8.35 a. m.																									
8.45 a. m.		7,034,580	73.0		2.5	1.0	526,010		12,442		238	518													
8.55 a. m.																									
9.05 a. m.		7,040,150	73.0		2.4	.0			14,472		239	624	500												
9.15 a. m.	300																								
9.25 a. m.		7,046,000	73.5		2.4	.2			16,501		240	624	480												
9.35 a. m.																									
9.45 a. m.		7,051,840	74.5	119,985	2.4	.3			18,530		240	624	500												

PRODUCER-GAS TESTS.

Log of producer-gas test No. 13, Indiana No. 2 coal, November 28, 29, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.				Temperatures (° C.).				Gas calorimeter.		B. T. U.	
				1.	2.	1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	Air entering (inches Hg.).	Gas leaving (inches Hg.).	Gas leaving (inches wa-ter).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.				
1		3	4	5	6	7	8	9		10	11	12	13	4	15	16		18	19	20	21	22	23				
2.35 p. m.		7,143,680	74.0		2.3	0.0	536,750			48,788		241	639				22.0	9.5	18.4	900	0.2	159.1	166.0				
2.45 p. m.																											
2.55 p. m.		7,149,680	73.5		2.3	.1				50,783		239	624		0.5	7.0	22.0	9.5	18.0	900	.2	151.9	157.8				
3.05 p. m.	300																										
3.15 p. m.		7,155,800	73.0		2.3	.2				52,798		240	624				22.0	9.5	17.7	1,350	.3	146.4	152.1				
3.25 p. m.																											
3.35 p. m.		7,162,000	72.5	120,810	2.3	.3	538,550			54,813		235	614				24.0	9.5	16.9	950	.2	139.6	146.0				
3.45 p. m.																											

PRODUCER-GAS TESTS.

OPERATIONS OF THE COAL-TESTING PLANT.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
9.48 a. m. ^a	10.2	0.2	11.2	8.5	1.2	68.7	100.0	81.5
11.50 a. m.	11.0	.2	10.6	6.3	8.4	63.5	100.0	150.0
1.50 p. m.	11.2	.4	12.2	14.1	4.3	57.8	100.0	137.4
3.50 p. m.	12.0	.0	9.8	8.9	5.1	64.2	100.0	120.0
5.50 p. m.	11.2	.0	11.6	7.6	5.4	64.2	100.0	126.8
7.50 p. m.	11.2	.2	9.6	13.1	4.9	61.0	100.0	131.1
9.50 p. m.	9.4	.2	12.8	11.2	8.1	58.3	100.0	169.9
11.50 p. m.	10.8	.2	17.2	9.2	6.3	56.3	100.0	159.1
1.50 a. m. ^b	10.2	.2	18.0	14.9	4.0	52.7	100.0	157.3
3.50 a. m.	10.6	.2	16.2	12.3	4.1	56.6	100.0	143.0
5.50 a. m.	10.8	.2	16.2	14.0	4.1	54.7	100.0	148.9
7.50 a. m.	11.0	.0	13.8	12.6	6.0	56.6	100.0	155.9
9.50 a. m.	11.0	.0	12.4	12.3	6.1	58.2	100.0	151.0
11.50 a. m.	12.2	.0	9.8	7.5	5.6	64.9	100.0	119.9
1.50 p. m.	12.2	.2	12.2	12.0	6.6	56.8	100.0	154.6

^a November 28.

^b November 29.

Producer-gas test No. 13A, ^a Indiana No. 2 coal.

[Recorded by W. C. Weidmann and Kurt Toensfeldt, November 28, 29, 1904.]

1. Duration of test, in hours.....	21
AVERAGE TEMPERATURE, ° F.	
2. Gas leaving producer	914
3-6. (See footnote on p. 1027.)	
OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
7. Total steam used by producer.....pounds..	5,313
8. Steam used by producer per hour.....do....	253
9. Equivalent in pounds of coal per hour.....	41.6
10. Equivalent in pounds of dry coal per hour.....	38
11. Equivalent in pounds of combustible per hour.....	34
12. Average horsepower required to drive auxiliary machinery.....	9.7
13. Total water used in scrubber and tar extractor.....cubic feet..	2,996
14. Cubic feet of water per hour per horsepower of producer plant.....	.570
15. Cubic feet of water per 1,000 cubic feet of gas produced.....	9

^a Gas-producer hopper leaked. Test No. 13 was divided into two parts, as explained on p. 1097.

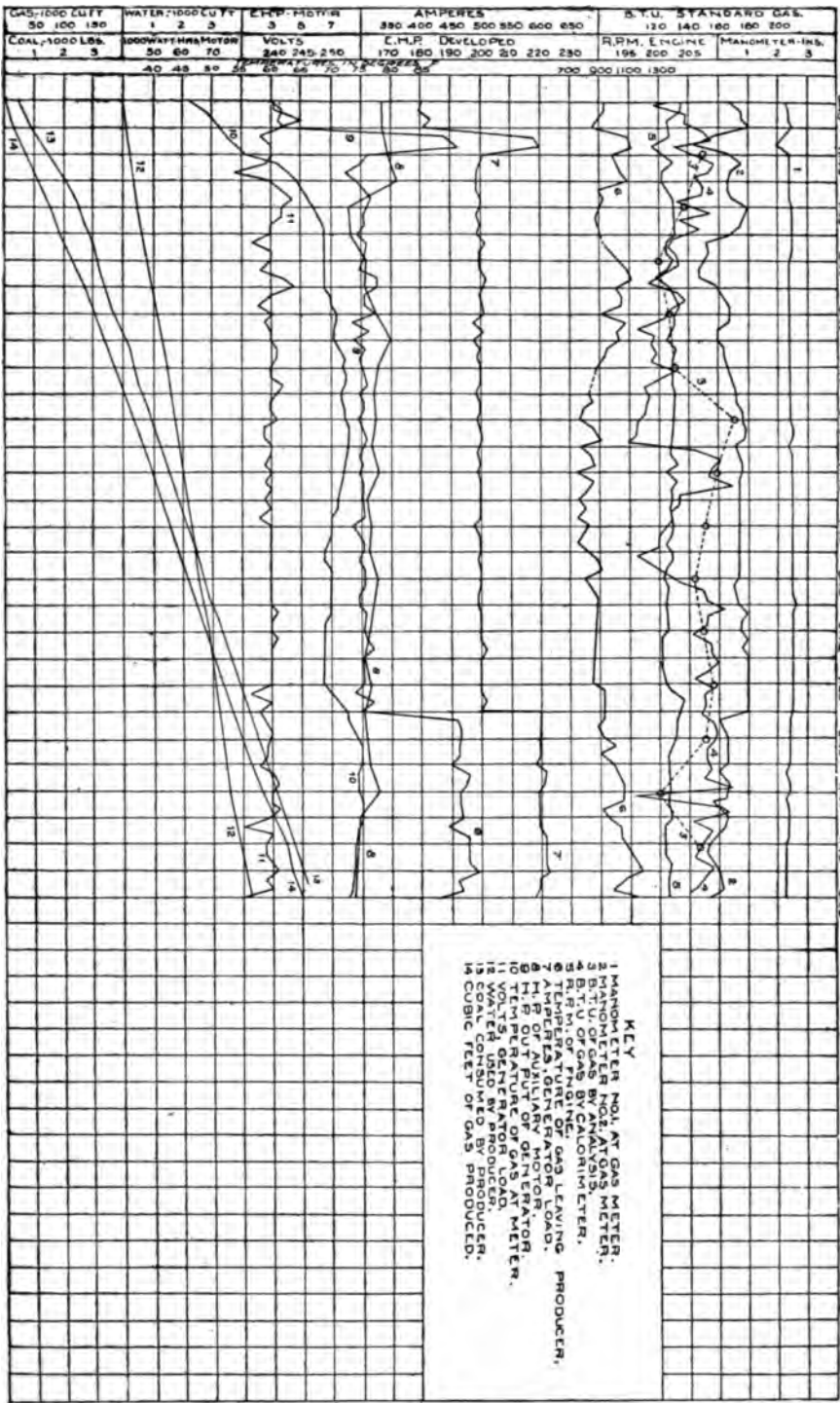


FIG. 116.—Graphic log sheet, producer-gas test, Indiana No. 2 coal.

OPERATIONS OF THE COAL-TESTING PLANT.

COAL CONSUMED IN PRODUCER.

16. Total coal consumed	pounds..	6,900
17. Moisture in coal	per cent..	8.72
18. Total dry coal consumed	pounds..	6,300
19. Refuse from dry coal	per cent..	10.66
20. Total refuse from coal	pounds..	672
21. Total combustible consumed	do.....	562.8

COAL PER HOUR.

22. Coal consumed in producer	pounds..	328.5
23. Dry coal consumed in producer	do.....	300
24. Combustible consumed in producer	do.....	268
25. Equivalent coal used by producer plant	do.....	370.1
26. Equivalent dry coal used by producer plant	do.....	338
27. Equivalent combustible used by producer plant	do.....	302

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired	8.55
29. Dry coal	7.80
30. Combustible	6.97

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired	11,822
32. Per pound of dry coal	12,953
33. Per pound of combustible	14,500
34. From coal as fired, per hour	3,883,000
35. From dry coal, per hour	3,883,000
36. From combustible, per hour	3,883,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total	333,000
38. Per hour	15,860
39. Per pound coal consumed in producer	48.3
40. Per pound dry coal consumed in producer	52.8
41. Per pound combustible consumed in producer	59.2
42. Per pound equivalent coal used by producer plant	42.8
43. Per pound equivalent dry coal used by producer plant	46.9
44. Per pound equivalent combustible used by producer plant	52.5

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot	139.6
46. Per pound dry coal burned in producer	7,380
47. Per hour per brake horsepower	11,300

PRODUCER-GAS TESTS.

1091

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	156.8
49. Electrical horsepower developed at switch board.....	166.5
50. Brake horsepower available for outside purposes.....	184.5
51. Brake horsepower developed at engine	196

EFFICIENCIES.

52. Of conversion and cleaning gas.....	.57
53. Of producer plant.....	.504

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes	2.10	1.91	1.71
55. Pounds consumed in producer per electrical horsepower developed at switch board	1.97	1.80	1.61
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes	1.78	1.63	1.45
57. Pounds consumed in producer per brake horsepower ^a developed at engine	1.68	1.53	1.37
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	2.36	2.16	1.93
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	2.22	2.03	1.81
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	2.01	1.83	1.64
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine	1.89	1.73	1.54

^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture	8.72	Carbon dioxide (CO ₂)	10.85
Volatile matter	39.60	Oxygen (O ₂)	.16
Fixed carbon	41.95	Carbon monoxide (CO)	13.45
Ash.....	9.73	Hydrogen (H ₂).....	11.29
	100.00	Methane (CH ₄)	5.52
Sulphur.....	4.23	Nitrogen (N ₂)	58.73
			100.00

OPERATIONS OF THE COAL-TESTING PLANT.

Producer-gas test No. 13B,^a Indiana No. 2 coal.

[Recorded by W. C. Weldmann and Kurt Toensfeldt, November 28, 29, 1904.]

1. Duration of test, in hours	7
AVERAGE TEMPERATURE, ° F.	
2. Gas leaving producer	1,031
3-6. (See footnote on p. 1027.)	
OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
7. Total steam used by producer	1,770
8. Steam used by producer per hour	253
9. Equivalent in pounds of coal per hour	41.6
10. Equivalent in pounds of dry coal per hour	38
11. Equivalent in pounds of combustible per hour	34
12. Average horsepower required to drive auxiliary machinery	9.6
13. Total water used in scrubber and tar extractor	991.5
14. Cubic feet of water per hour per horsepower of producer plant	.57
15. Cubic feet of water per 1,000 cubic feet of gas produced	8.12
COAL CONSUMED IN PRODUCER.	
16. Total coal consumed	2,100
17. Moisture in coal	8.72
18. Total dry coal consumed	1,917
19. Refuse from dry coal	10.66
20. Total refuse from coal	204.3
21. Total combustible consumed	1,712.7
COAL PER HOUR.	
22. Coal consumed in producer	300
23. Dry coal consumed in producer	274
24. Combustible consumed in producer	244.8
25. Equivalent coal used by producer plant	338
26. Equivalent dry coal used by producer plant	312
27. Equivalent combustible used by producer plant	278.8

^a Gas-producer hopper leaked.

PRODUCER-GAS TESTS.

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COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired	7.80
29. Dry coal.....	7.10
30. Combustible	6.40

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	11,822
32. Per pound of dry coal	12,953
33. Per pound of combustible.....	14,500
34. From coal as fired, per hour	3,550,000
35. From dry coal, per hour.....	3,550,000
36. From combustible, per hour	3,550,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	122,160
38. Per hour	17,450
39. Per pound coal consumed in producer	58.2
40. Per pound dry coal consumed in producer	63.6
41. Per pound combustible consumed in producer.....	71.3
42. Per pound equivalent coal used by producer plant.....	51.6
43. Per pound equivalent dry coal used by producer plant.....	55.9
44. Per pound equivalent combustible used by producer plant	62.6

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	159.3
46. Per pound dry coal burned in producer.....	10,140
47. Per hour per brake horsepower	11,750

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes	191.4
49. Electrical horsepower developed at switch board	201
50. Brake horsepower available for outside purposes	225
51. Brake horsepower developed at engine	236.5

EFFICIENCIES.

52. Of conversion and cleaning gas	.783
53. Of producer plant.....	.684

OPERATIONS OF THE COAL-TESTING PLANT.

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes	1.57	1.43	1.28
55. Pounds consumed in producer per electrical horsepower developed at switch board	1.49	1.36	1.22
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes	1.33	1.22	1.09
57. Pounds consumed in producer per brake horsepower ^a developed at engine	1.27	1.16	1.03
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	1.77	1.63	1.46
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board	1.68	1.55	1.39
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes	1.50	1.39	1.24
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine	1.43	1.32	1.18

^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture	8.72	Carbon dioxide (CO ₂)	11.80
Volatile matter	39.60	Oxygen (O ₂)	.07
Fixed carbon	41.95	Carbon monoxide (CO)	11.46
Ash	9.73	Hydrogen (H ₂)	10.60
	100.00	Methane (CH ₄)	6.10
Sulphur	4.23	Nitrogen (N ₂)	59.97
			100.00

GAS ENGINE.

Following are records of the tests on gas engine:

Report of gas-engine test No. 13A.

Recorded by K. Toensfeldt and W. C. Weidmann, November 28, 29, 1904.	
Producer test No. 13 A.	
Coal: General number, Indiana No. 2; special number G. P. 13A. Car initials and number, Southern 63062.	
Duration of test, in hours.....	21
Revolutions per minute (mean).....	202
Explosions per minute (mean).....	101
Cubic feet gas per hour, by meter.....	16,400
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	15,850
Maximum pressure:	
First cylinder.....	212.91
Second cylinder.....	200.72
Third cylinder.....	211.63
Pressure at release:	
First cylinder.....	28.18
Second cylinder.....	29.45
Third cylinder.....	25.81
Mean effective pressure:	
First cylinder.....	51.59
Second cylinder.....	52.59
Third cylinder.....	49.13
Indicated horsepower:	
First cylinder.....	82.16
Second cylinder.....	83.71
Third cylinder.....	76.86
Total indicated horsepower.....	242.73
Horsepower delivered (electrical horsepower).....	166.5
Mechanical efficiency (engine and generator combined).....per cent..	68.6
Cubic feet standard gas per hour per indicated horsepower.....	65.3
Cubic feet standard gas per hour per electrical horsepower.....	95.1

Report of gas-engine test No. 13B.

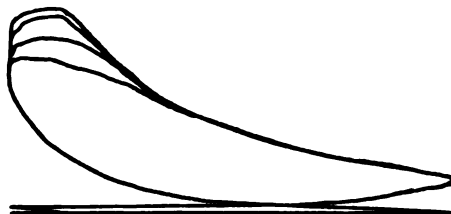
Recorded by K. Toensfeldt and W. C. Weidmann, November 28, 29, 1904.

Producer test No. 13B.

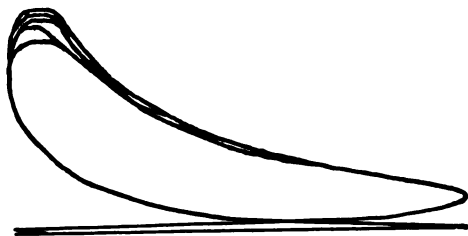
Coal: General number, Indiana No. 2; special number, G. P. 13B. Car initials and number, Southern 63062.

Duration of test, in hours.....	7
Revolutions per minute (mean).....	201.8
Explosions per minute (mean).....	100.9
Cubic feet gas per hour, by meter.....	18,200
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	17,440
Maximum pressure:	
First cylinder.....	277.50
Second cylinder.....	251
Third cylinder.....	223.75
Pressure at release:	
First cylinder.....	30
Second cylinder.....	28.5
Third cylinder.....	27.5
Mean effective pressure:	
First cylinder.....	59
Second cylinder.....	57.5
Third cylinder.....	53.25
Indicated horsepower:	
First cylinder.....	94.05
Second cylinder.....	91.65
Third cylinder.....	85.65
Total indicated horsepower.....	271.35
Horsepower delivered (electrical horsepower).....	201
Mechanical efficiency (engine and generator combined)..... per cent..	74
Cubic feet standard gas per hour per indicated horsepower.....	64.3
Cubic feet standard gas per hour per electrical horsepower.....	86.8

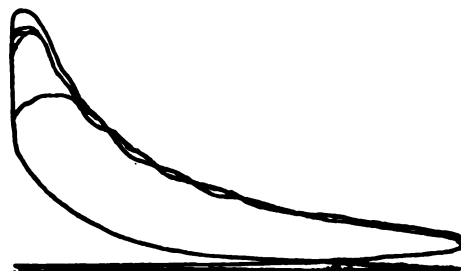
After one or two attempts to carry full load the idea was abandoned, at least during the early part of the run. The failure of the engine to carry full load was due to the late ignition setting. A load of 500 amperes was finally determined upon and the report marked "Test No. 13A" covers the records from 11.45 a. m. November 28 to 8.45 a. m. November 29, a period of twenty-one hours. At 8.45 a. m. November 29 the load was raised to the full amount (600 amperes) and carried with ease throughout the remainder of the test. Test No. 13B covers this portion of the run.



Right cylinder. M. E. P., 55; Max., 166; Rel., 34; I. H. P., 86.8.



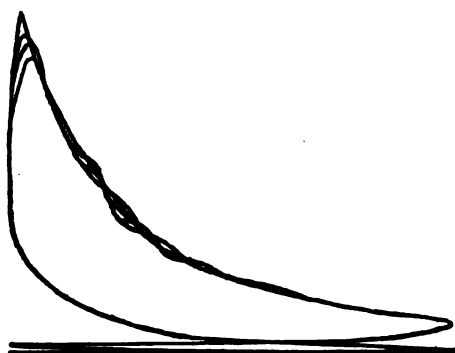
Center cylinder. M. E. P., 56; Max., 180; Rel., 34; I. H. P., 88.4.



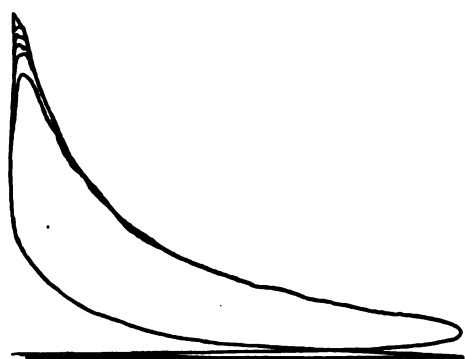
Left cylinder. M. E. P., 51; Max., 200; Rel., 28; I. H. P., 80.6.

Indicator diagrams taken November 28, 1904, during gas-engine test No. 13A, on Indiana No. 2 coal. Revolutions per minute, 200.5.

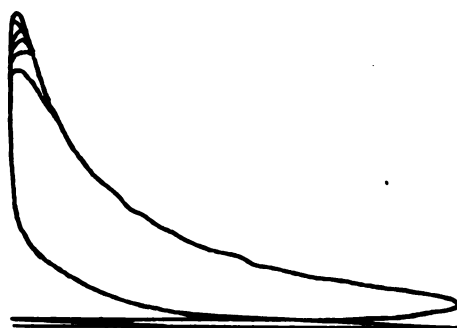
The gas produced was somewhat difficult to clean, and contained a high percentage of sulphur. During the early part of the test the gas was low in heat value, but improved in quality after the fuel bed had been increased in depth. Good results may therefore be obtained from this coal if it is properly fired in the producer. Sixty gallons of tar were extracted.



Right cylinder. M. E. P., 68; Max., 260; Rel., 28; I. H. P., 100.2.



Center cylinder. M. E. P., 60; Max., 280; Rel., 30; I. H. P., 95.15.



Left cylinder. M. E. P., 54; Max., 260; Rel., 26; I. H. P., 85.9.

Indicator diagrams taken November 29, 1904, during gas-engine test No. 13B, on Indiana No. 2 coal. Revolutions per minute, 202.

Two sets of indicator cards are shown, both with the same ignition setting. The first set was taken at the beginning of the run on reduced load. Late ignition and slow combustion are shown. The second set was taken near the end of the run, when the engine was carrying full load, and although the ignition setting was not touched, the ignition appears normal.

INDIAN TERRITORY No. 1.

GENERAL RESULTS.

The general results of tests of Indian Territory No. 1 coal are shown in the following tables:

Log of producer-gas test No. 1, Indian Territory No. 1 coal, October 3-6, 1904.
[Coal from mine No. 1 of the Whitehead Coal and Mining Company, Henryetta, Ind. T.]

PRODUCER-GAS TESTS.																											
Time	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of gas (° F.).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer.		Manometers at producer.		Temperatures (° C.).				Gas calorimeter.				B. T. U.	
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23					
																							1.	2.	1.	2.	Volts.	Amps.	Air entering mer. (inches mercury).	Gas leaving wa-ter. (inches wa-ter).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Liters of gas.	As read.	Standardized.
12.20 p. m. ^a		464,950	74.0	17,661	2.3	1.1	(b)		91,801	91,801	240	620															
12.40 p. m.		470,975	75.0		2.3	1.1			93,782	93,782	238	620															
12.45 p. m.																											
1 p. m.	300	477,000	75.5		2.3	1.1			95,760	95,760	239	620															
1.15 p. m.																											
1.20 p. m.		482,900	76.0	17,817	2.2	1.1			97,743	97,743	240	620															
1.40 p. m.	300	489,300	75.5		2.2	1.0			99,721	99,721	240	620															
1.45 p. m.																											
2 p. m.		495,750	75.5		2.2	1.0			1,098	1,098	240	620															
2.15 p. m.																											
2.20 p. m.		502,200	76.0	17,955	2.2	.9			3,676	3,676	238	620															
2.30 p. m.	300																										
2.40 p. m.		508,690	76.5		2.2	.8			5,659	5,659	240	620															
2.45 p. m.																											
3 p. m.		515,210	76.5		2.2	.8			7,642	7,642	239	620															
3.10 p. m.	300																										
3.15 p. m.																											
3.20 p. m.		521,825	77.0	18,084	2.2	.8			9,615	9,615	238	620															
3.40 p. m.		528,600	77.0		2.2	.7			11,582	11,582	238	620															
3.45 p. m.																											
3.50 p. m.	300																										
4 p. m.		534,975	77.5		2.2	.8			13,561	13,561	240	620															
4.15 p. m.																											
4.20 p. m.		540,975	77.0	18,212	2.2	1.0			15,545	15,545	240	620															

^a October 3. Barometer 29.56 inches.

^b Watt meter not connected.

PRODUCER-GAS TESTS.

Log of producer-gas test No. 1, Indian Territory No. 1 coal, October 3-6, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer.	Manometers at producer.		Gas calorimeter.						B. T. U.	
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Temperatures (° C.).		Cubic centimeters of water collected.	Liters of gas.	As read.	Standardized.	
																	Inlet.	Outlet.					
1		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
4.30 p. m.	300																						
4.40 p. m.		546,980	76.0		2.2	1.0			17,530	17,550	240	620											
4.45 p. m.																							
5 p. m.	300	553,250	75.5		2.2	1.0			19,512	19,512	240	620				22.6	24.00	31.76	2,850	15	148.7	153.4	
5.20 p. m.		569,375	75.0	18,360	2.2	1.0			21,500	21,500	242	620											
7.30 a. m. ^a	200																						
7.40 a. m.		561,850	67.0	18,734	2.4	1.2			22,743	22,743	240	620											
8 a. m.	300	568,150	69.5		2.4	1.2			24,725	24,725	240	620											
8.20 a. m.		573,750	71.5		2.3	1.2			26,715	26,715	240	646											
8.40 a. m.		579,175	74.0		2.3	1.3			28,700	28,700	239	620				26.0	23.50	30.40	3,250	15	164.5	175.0	
8.45 a. m.	300																						
8.55 a. m.		584,850	75.5		2.3	1.1			30,686	30,686	239	640				28.5	24.40	31.41	3,150	15	164.8	174.1	
9 a. m.																							
9.20 a. m.		590,950	75.5	18,975	2.3	1.1			32,685	32,685	240	640				27.0	24.40	31.14	3,150	15	156.0	166.7	
9.30 a. m.	300																						
9.40 a. m.		597,150	76.0		2.3	1.1			34,678	34,678	239	630				31.0	24.75	31.86	3,000	15	157.8	169.7	
10 a. m.		603,500	76.0		2.3	.9			36,672	36,672	240	630				28.0	24.60	30.71	2,720	15	129.8	130.8	
10.15 a. m.	300																						
10.20 a. m.		610,125	77.0	19,133	2.2	.8			38,700	38,700	239	630				29.5	24.87	31.11	3,270	15	151.8	153.6	
10.40 a. m.		616,750	77.5		2.2	1.0			40,741	40,741	240	630				28.5	25.00	31.57	3,190	15	162.0	157.6	
11 a. m.	300	623,310	77.5		2.2	.8			42,769	42,769	240	630				28.5	24.80	31.10	3,230	15	149.4	160.3	
11.20 a. m.		630,100	77.5		2.2	.8			44,779	44,779	240	630											
11.25 a. m.																27.5	24.80	30.90	3,350	15	149.6	152.2	
11.40 a. m.		636,810	77.5		2.2	.6			46,792	46,792	239	630				27.0	24.80	30.27	3,000	15	145.5	154.6	
11.45 a. m.	300																						

^a October 4. Barometer 29.55 inches.

Log of producer-gas test No. 1, Indian Territory No. 1 coal, October 3-6, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer.	Manometers at producer.		Temperatures (° C.).				Gas calorimeter.				
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Water.		Cubic centimeters of water collected.	Liters of gas.	As read.	Standardized.		
																	Inlet.	Outlet.						
																							18	19	20	21	22	23
3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23				
12 m.		643, 675	78.0		2.2	0.6			48, 800	48, 800	239	630												
12.05 p. m.																								
12.20 p. m.		650, 500	78.5		2.2	.6			50, 808	50, 808	239	630												
12.25 p. m.																								
12.40 p. m.		657, 100	78.5	19, 475	2.2	.7			52, 818	52, 818	240	630												
12.45 p. m.	300																							
1 p. m.		663, 700	78.5		2.2	.8			54, 834	54, 834	239	630												
1.20 p. m.		670, 290	78.5		2.2	.8			56, 850	56, 850	239	630												
1.25 p. m.																								
1.40 p. m.		676, 950	79.0		2.2	.7			58, 864	58, 864	239	630												
1.45 p. m.	300																							
2 p. m.		683, 600	79.0		2.2	.6			60, 870	60, 870	240	630												
2.05 p. m.																								
2.20 p. m.		690, 225	79.5		2.2	.6			62, 872	62, 872	240	640												
2.30 p. m.																								
2.40 p. m.	300	696, 950	79.0	19, 820	2.2	.6			64, 874	64, 874	239	640												
2.50 p. m.																								
3 p. m.		703, 700	79.0		2.2	.6			66, 874	66, 874	241	640												
3.10 p. m.																								
3.20 p. m.		710, 425	79.0		2.2	.6			68, 875	68, 875	241	635												
3.40 p. m.		716, 975	79.5		2.2	.7			70, 870	70, 870	240	640												
3.45 p. m.	300																							
4 p. m.		723, 525	78.5		2.2	.8			72, 868	72, 868	240	640												
4.10 p. m.																								
4.20 p. m.		730, 100	78.0		2.25	.8			74, 870	74, 870	240	640												

Log of producer-gas test No. 1, Indian Territory No. 1 coal, October 3-6, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer.	Manometers at producer.		Gas calorimeter.				H. P. U. Standardized.		
				1.	2.	1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercury).	Gas leaving (inches water).	Temperatures (° C.).		Cubic centimeters of water collected.	Liters of gas.			
																	Gas.	Inlet.				Outlet.	Water.
1		3	4	5	6	7	8	9		10	11	12	13	14	15	16	17	18	19	20	21	22	23
4.40 p. m.		736,610	77.5	20,130	2.2	0.8				76,870		241	635				24.5	24.50	30.10	3,600	15	145.8	157.0
4.45 p. m.	300																						
5 p. m.		743,200	77.0		2.2	.8				78,874		241	635				23.8	24.40	29.43	4,000	15	139.5	145.3
5.10 p. m.																							
5.20 p. m.		749,700	76.5		2.2	.8				80,876		241	645										
5.40 p. m.		756,200	76.5	20,290	2.2	.8				82,882		242	640										
9 a. m. a.	300	762,650	74.5	21,870	2.3	1.1				85,323		240	640										
9.20 a. m.		768,800	75.0		2.3	1.1				87,346		240	650										
9.40 a. m.		775,050	75.5		2.4	1.1				89,354		240	640										
9.45 a. m.																	25.3	23.60	29.17	3,900	15	153.5	169.4
10 a. m.	300	781,600	75.5		2.4	1.1				83,364		240	640										
10.05 a. m.																							
10.20 a. m.		787,800	76.0		2.3	1.2				85,376		240	635				26.4	23.20	28.80	3,900	15	153.7	171.4
10.25 a. m.																							
10.40 a. m.		793,910	76.0		2.3	1.0				87,390		240	635				25.8	23.50	29.00	3,780	15	145.7	162.7
10.45 a. m.																							
11 a. m.	300	800,200	75.5	21,160	2.3	.9				89,403		240	635				26.0	23.50	28.60	4,000	15	140.4	159.4
11.20 a. m.		806,600	75.0		2.3	1.1				41,408		240	640				26.0	23.40	28.27	4,190	15	141.8	159.8
11.25 a. m.																							
11.40 a. m.		812,954	75.5		2.2	1.0				43,417		240	635				26.7	23.18	28.40	3,900	15	150.3	159.8
11.45 a. m.	300																						
12 m.		819,410	75.5		2.2	.9				45,430		240	646				26.8	23.60	28.90	3,880	15	138.0	159.5
12.15 p. m.																							
12.30 p. m.		825,750	75.0		2.3	.8				47,434		240	646				25.3	23.40	28.40	4,100	15	143.0	160.2
12.40 p. m.		832,210	75.0		2.3	.8				49,438		240	346										

a October 5. Barometer 28.75 inches.

Log of producer-gas test No. 1, Indian Territory No. 1 coal, October 3-6, 1904—Continued.

Time.	Coal consumed by producer (pounds).			Temperature of gas (° F.).			Water meter (cubic feet).			Manometers at gas meter (inches water).			Auxiliary motors.			Speed counters on gas engine.			Load.			Temperature of gas leaving producer (° C.).			Manome- ters at pro- ducer.			Gas calorimeter.										B. T. U.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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Log of producer-gas test No. 1, Indian Territory No. 1 coal, October 3-6, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).				Manometers at producer.		Temperatures (° C.).				Gas calorimeter.				B. T. U.
				1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	14	15	16	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Liters of gas.	As read.	Standardized.					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23				
5 p. m.		915, 225	75.0	22, 020	2.3	1.0			75, 596	33, 596	240	646														
5.20 p. m.		921, 400	74.0		2.3	.9			77, 615	35, 615	240	640				25.8	22.70	27.88	3, 960	11	144.0	160.7				
5.30 p. m.	300																									
5.40 p. m.		927, 750	73.5		2.3	.8			79, 625	37, 615	241	640														
6 p. m.	b 300	934, 260	73.0	22, 144	2.3	.7				39, 640	239	640														
8 a. m. c.	d 200	937, 500	65.5	22, 410	2.3	.7			82, 935	40, 935	239	650										(a)				
8.20 a. m.		943, 775	70.0		2.3	.9			84, 948	42, 948	240	646										(a)				
8.40 a. m.		949, 610	71.5		2.4	.8			86, 967	44, 967	239	646														
9 a. m.	300	955, 250	72.5		2.4	.7			88, 985	46, 985	239	635				31.3	22.80	33.80	2, 000	15	151.5	175.6				
9.20 a. m.		960, 910	73.0		2.4	.7			91, 001	49, 001	238	635				32.0	23.00	25.19	1, 800	15	155.5	175.4				
9.40 a. m.		966, 710	73.0		2.4	.6			93, 012	51, 012	239	635														
10 a. m.	300	974, 000	73.5		2.3	.9			95, 015	53, 015	240	640				32.0	23.00	30.64	2, 750	15	148.2	168.4				
10.20 a. m.		980, 000	74.0		2.3	.9			97, 027	55, 027	240	640				31.7	23.30	31.49	2, 050	12	146.5	168.6				
10.40 a. m.		986, 100	74.5		2.3	.9			99, 046	57, 046	240	640														
10.50 a. m.																31.3	23.20	31.12	2, 650	15	148.0	167.6				
11 a. m.	300	992, 025	75.0	22, 670	2.3	1.0			1, 058	59, 058	240	640														
11.20 a. m.		998, 075	75.5		2.4	1.1			3, 078	61, 078	240	640				29.2	23.10	31.10	2, 700	15	151.7	170.8				
11.40 a. m.		1, 004, 010	75.5		2.4	1.1			5, 096	63, 096	240	640														
12 m.	300	1, 010, 160	75.5		2.4	1.1			7, 113	65, 113	240	640														
12.10 p. m.																26.0	23.20	30.59	2, 800	15	144.4	162.3				
12.20 p. m.		1, 016, 200	75.5		2.4	1.0			9, 130	67, 130	240	640														
12.40 p. m.		1, 022, 360	75.0		2.3	1.1			11, 177	69, 177	237	640														
12.50 p. m.																26.0	22.90	29.85	2, 900	15	144.8	157.9				
1 p. m.	300	1, 028, 550	75.0		2.3	1.1			13, 191	71, 191	240	640														

^a Calorimeter readings discontinued after 5.20 p. m. on account of low gas pressure in calorimeter pipe.
^b Bad hole in fire. Coal charged without weighing. Estimated as given.
^c October 6. Barometer 29.78 inches.
^d Charge of coal estimated.

Log of producer-gas test No. 1, Indian Territory No. 1 coal, (October 3-6, 1904—Continued.

[illegible]

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.
12.20 p. m. <i>a</i>	6.6	0.2	22.8	11.0	3.2	56.2	100.0
1.20 p. m.	6.0	.2	23.7	16.8	5.6	47.7	100.0
2.20 p. m.	8.8	.0	23.6	2.1	5.2	60.3	100.0
4.20 p. m. <i>b</i>	9.6	.2	16.8	11.4	3.4	58.6	100.0
8.25 a. m. <i>c</i>	7.4	.0	22.6	11.0	4.6	54.4	100.0
10.25 a. m.	8.4	.2	17.4	5.3	3.5	65.2	100.0
12.25 p. m.	8.6	.2	17.0	5.7	11.1	57.4	100.0
2.25 p. m.	9.2	.6	15.4	4.7	5.3	64.8	100.0
8.10 a. m. <i>d</i>	8.8	.0	20.8	3.4	3.8	63.2	100.0
9.10 a. m.	5.4	.0	23.6	5.4	5.6	60.0	100.0
1.10 p. m.	9.2	.0	17.4	4.7	4.9	63.8	100.0
3.10 p. m.	10.0	.0	17.0	12.9	3.9	56.2	100.0
5.10 p. m.	9.8	.0	15.8	12.4	4.2	57.8	100.0
8.25 a. m. <i>e</i>	5.4	.2	23.2	7.8	3.9	59.5	100.0
10.10 a. m.	8.4	.0	17.3	5.1	5.5	63.7	100.0
12.10 p. m.	9.0	.0	18.2	6.1	5.3	61.4	100.0
2.10 p. m.	9.6	.0	17.0	4.9	4.6	63.9	100.0

a October 3. *b* 3.20 gas sample missed. *c* October 4. *d* October 5. *e* October 6.

Producers-gas test No. 1, Indian Territory No. 1 coal.

[Recorded by M. H. Mount and R. E. Peshak, October 3-6, 1904.]

1. Duration of test, in hours 31

AVERAGE TEMPERATURE, ° F.

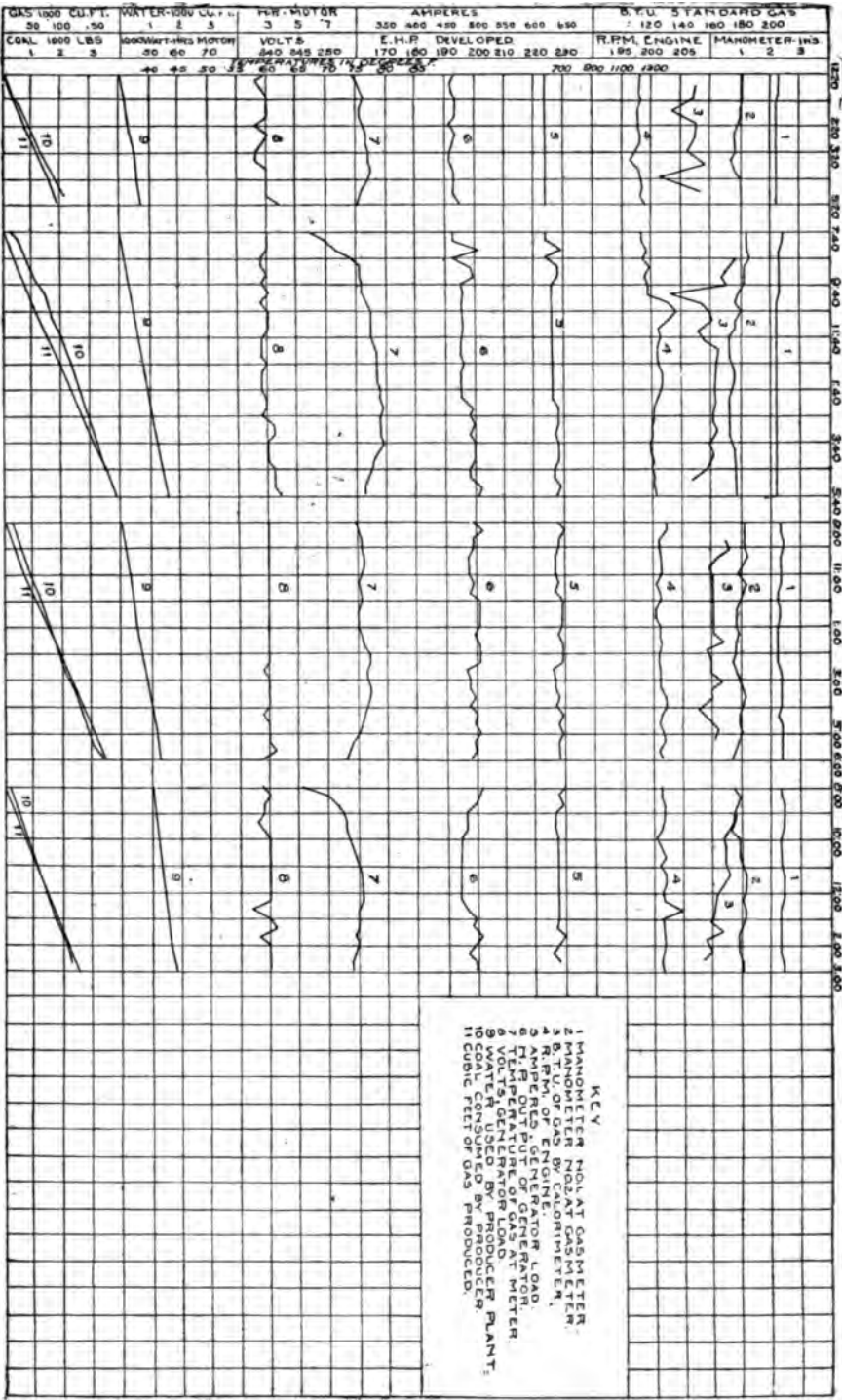
2. Gas leaving producer

3-6. (See footnote on p. 1027.)

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

7. Total steam used by producer	pounds..	6,640
8. Steam used by producer per hour	do.....	214
9. Equivalent in pounds of coal per hour		31.65
10. Equivalent in pounds of dry coal per hour		30
11. Equivalent in pounds of combustible per hour		27.30
12. Average horsepower required to drive auxiliary machinery		8
13. Total water used in scrubber and tar extractor	cubic feet..	4,289
14. Cubic feet of water per hour per horsepower of producer plant		.553
15. Cubic feet of water per 1,000 cubic feet of gas produced		7.42

FIG. 117.—Graphic log sheet, producer-gas test, Indian Territory No. 1 coal.



OPERATIONS OF THE COAL-TESTING PLANT.

COAL CONSUMED IN PRODUCER.

16. Total coal consumed	pounds..	11,200
17. Moisture in coal	per cent..	5
18. Total dry coal consumed	pounds..	10,640
19. Refuse from dry coal	per cent..	8.98
20. Total refuse from coal	pounds..	955
21. Total combustible consumed	do....	9,685

COAL PER HOUR.

22. Coal consumed in producer	pounds..	361
23. Dry coal consumed in producer	do....	344
24. Combustible consumed in producer	do....	312
25. Equivalent coal used by producer plant	do....	392.7
26. Equivalent dry coal used by producer plant	do....	374
27. Equivalent combustible used by producer plant	do....	339.3

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired		9.38
29. Dry coal		8.94
30. Combustible		8.11

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired		12,787
32. Per pound of dry coal		13,455
33. Per pound of combustible		14,800
34. From coal as fired, per hour		4,620,000
35. From dry coal, per hour		4,620,000
36. From combustible, per hour		4,620,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total		577,000
38. Per hour		18,613
39. Per pound coal consumed in producer		51.6
40. Per pound dry coal consumed in producer		54.1
41. Per pound combustible consumed in producer		59.4
42. Per pound equivalent coal used by producer plant		47.4
43. Per pound equivalent dry coal used by producer plant		49.9
44. Per pound equivalent combustible used by producer plant		54.6

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot		159.15
46. Per pound dry coal burned in producer		8,620
47. Per hour per brake horsepower		12,350

PRODUCER-GAS TESTS.

1109

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	198
49. Electrical horsepower developed at switch board	204
50. Brake horsepower available for outside purposes	230
51. Brake horsepower developed at engine	240

EFFICIENCIES.

52. Of conversion and cleaning gas	.64
53. Of producer plant	.586

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes	1.84	1.76	1.59
55. Pounds consumed in producer per electrical horsepower developed at switch board	1.77	1.69	1.53
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes	1.57	1.50	1.36
57. Pounds consumed in producer per brake horsepower ^a developed at engine	1.50	1.43	1.30
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	2.00	1.91	1.73
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board	1.92	1.83	1.66
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes	1.71	1.62	1.47
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine	1.64	1.56	1.41

^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture	5.00	Carbon dioxide (CO ₂).....	8.25
Volatile matter	36.51	Oxygen (O ₂)	.11
Fixed carbon	49.98	Carbon monoxide (CO)	19.39
Ash.....	8.51	Hydrogen (H ₂)	7.69
	100.00	Methane (CH ₄).....	4.92
Sulphur.....	1.43	Nitrogen (N ₂)	59.64
			100.00

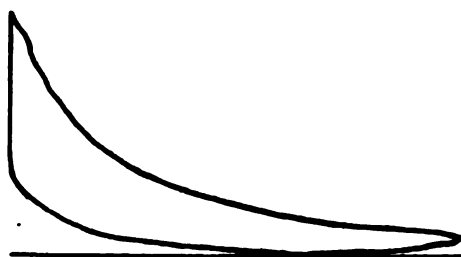
GAS ENGINE.

Test No. 1 was divided into sections, as follows:

	Hours.
October 3, 12.20 p. m. to 5.20 p. m	5
October 4, 7.40 a. m. to 5.40 p. m	10
October 5, 9 a. m. to 6 p. m.....	9
October 6, 8 a. m. to 3 p. m.....	7
	31

Item 12, the average horsepower required to drive auxiliary machinery, was not determined during this test. The value used, viz, 8 horsepower, was obtained from later tests and substituted in test No. 1.

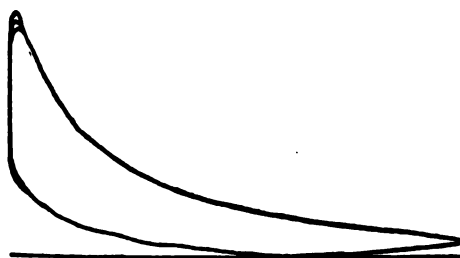
This is a moderately free-burning coal. It caked fairly well in the producer and made a good top crust, which was easily worked. It was charged into the producer after being crushed and screened over a half-inch screen. This was done while it was wet, and considerable slack was carried over with the lumps. It may be considered a good producer coal.



Right cylinder. M. E. P., 66; Max., 304; Rel., 30; I. H. P., 105.



Center cylinder. M. E. P., 65; Max., 312; Rel., 32; I. H. P., 103.4.



Left cylinder. M. E. P., 64; Max., 300; Rel., 32; I. H. P., 102.

Indicator diagrams taken October 5, 1904, during gas-engine test No. 1, on Indian Territory No. 1 coal. Scale of spring, 120; revolutions per minute, 202.

Two and one-half barrels of tar were extracted during the thirty-one hours of this run.

The indicator cards for test No. 1 were taken with a 240-pound spring, which accounts for the comparatively small card.

It will be noticed that the ignition setting is a trifle early.

PRODUCER-GAS TESTS.

1111

Report of gas-engine test No. 1.

Recorded by R. W. Cummings and W. C. Weidmann, October 3-6, 1904.

Producer test No. 1.

Coal: General number, No. 6, Indian Territory No. 1; special number, G. P. 1. Car initials and number, Frisco 6704.

Duration of test, in hours.....	31
Revolutions per minute (mean).....	200.5
Explosions per minute (mean).....	100
Cubic feet gas per hour, by meter.....	18,990
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	18,225
Maximum pressure:	
First cylinder.....	280.5
Second cylinder.....	303.2
Third cylinder.....	283.4
Pressure at release:	
First cylinder.....	33.4
Second cylinder.....	32.5
Third cylinder.....	30.3
Mean effective pressure:	
First cylinder.....	64.9
Second cylinder.....	65.7
Third cylinder.....	63.3
Indicated horsepower:	
First cylinder.....	103.5
Second cylinder.....	103.92
Third cylinder.....	99.01
Total indicated horsepower.....	306.4
Horsepower delivered (electrical horsepower).....	204
Mechanical efficiency (engine and generator combined).....per cent..	66.6
Cubic feet standard gas per hour per indicated horsepower.....	59.5
Cubic feet standard gas per hour per electrical horsepower.....	91.4

INDIAN TERRITORY No. 4.

GENERAL RESULTS.

The general results of tests of Indian Territory No. 4 coal are shown in the following tables:

Log of producer-gas test No. 20, Indian Territory No. 4 coal, January 23, 24, 1905.
[Coal from mine No. 5 of the Western Coal and Mining Company, Lehigh, Ind. T.]

Time.	(Coal consumed by producer (pounds).)	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).			Auxiliary motors.		Speed counters on gas engine.			Load.		Temperature of gas leaving producer (° C.).			Manometer at producer.			Gas calorimeter.				B. T. U.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	13	14	15	16	Gas (° F.).	Temperatures.		Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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a January 23. Average barometer for entire test, 30.39 inches.

b Calorimeter burner clogged.

Log of producer-gas test No. 20, Indian Territory No. 4 coal, January 23, 24, 1905—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Gas calorimeter.				B. T. U.	
		3	4	5	6	7	8		9	10	11	12	13	14	15	16	17	18	Temperatures.		Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.	
							1.	2.											Inlet.	Outlet.					Water (° C.).
3.20 p. m.		73,200	69	20,389	2.5	1.5	973,010			36,498	240	619	315				62	4.2	14.6	900	0.2	185.7	183.5		
3.40 p. m.		77,900	69		2.5	1.5				38,535	238	614	360				62	4.2	14.3	920	.2	184.1	182.1		
4 p. m.		82,820	68		2.5	1.3				40,565	235	619	350				61	4.3	15.4	900	.2	176.2	173.7		
4.15 p. m.	300																								
4.20 p. m.		87,740	68		2.5	1.0	975,050			42,586	237	624	300	0.2	4.0		62	4.4	16.0	750	.2	172.6	170.4		
4.40 p. m.		92,410	68		2.5	1.4				44,632	237	629	330				63	4.4	15.9	800	.2	182.5	180.7		
5 p. m.		97,160	68		2.5	1.4				46,662	236	619	370				62	4.4	15.3	820	.2	177.0	174.7		
5.20 p. m.		102,150	68	20,738	2.5	1.3	977,010			48,680	238	624	400				60	4.3	14.2	900	.2	180.5	177.5		
5.30 p. m.	300																								
5.40 p. m.		107,340	67		2.5	1.3				50,690	238	624	300	.3	4.0		60	4.3	15.0	770	.2	163.0	160.4		
6 p. m.		112,140	67		2.5	1.4				52,725	238	619	340				58	4.2	15.6	800	.2	180.9	177.3		
6.20 p. m.		116,840	67		2.5	1.3	979,090			54,750	238	624	380				58	4.2	14.8	820	.2	172.6	168.3		
6.30 p. m.	300																								
6.40 p. m.		121,940	67		2.4	1.2				56,743	240	624	320				58	4.3	13.3	960	.2	171.4	168.0		
7 p. m.		126,900	66		2.4	1.2				58,770	239	624	390				58	4.3	15.1	820	.2	175.8	172.3		
7.15 p. m.	300																								
7.20 p. m.		131,930	66		2.3	1.1	981,300			66,778	235	614	350	.3	4.0		57	4.2	13.5	930	.2	168.6	165.0		
7.40 p. m.		137,000	66		2.4	1.3				62,785	240	624	350				57	4.2	14.6	820	.2	169.0	165.4		
8 p. m.	300				2.4	1.3				64,812	242	624	340				56	4.2	15.8	750	.2	172.6	168.7		
8.20 p. m.		146,650	66		2.4	1.4	983,550			66,847	241	624	300	.4	5.0		56	4.2	15.9	750	.2	174.2	170.2		
8.40 p. m.		151,200	66		2.4	1.4				68,887	241	624	340				55	4.2	16.1	770	.2	181.7	177.1		
9 p. m.		155,900	66		2.4	1.4				70,915	239	624	300				55	4.2	15.4	900	.2	177.8	173.3		
9.15 p. m.	300																								
9.20 p. m.		160,800	66		2.4	1.4	985,600			72,950	240	634	310				55	4.2	14.1	800	.2	157.1	153.2		
9.40 p. m.		165,780	66		2.4	1.4				74,970	240	624	310	.3	4.5		55	4.2	15.6	750	.2	169.4	165.1		
10 p. m.		170,500	65		2.4	1.4				76,991	238	614	360				55	4.1	16.0	810	.2	174.9	170.5		

Log of producer-gas test No. 20, Indian Territory No. 4 coal, January 23, 24, 1905—Continued.

Time.	Coal consumed by producer (pounds).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water)		Auxiliary motors.		Speed counters on gas engine.	Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Temperatures.				Gas calorimeter.		B. T. U.				
				1.	2.	Watt meter.	Ammeter.		1.	2.		Volts.	Amperes.	Air entering (inches mercury).	Gas leaving (inches wa- ter).	Gas (° F.).	Inlet.	Outlet.	Cubic centimeters of water collected.			Cubic feet of gas.	As read.	Standardized.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
10.15 p. m.	300	175,460	65	21,552	2.4	1.2	987,600			78,982	230	624	330			55	4.1	12.5	870	0.2	144.8	141.2		
10.20 p. m.		180,740	65		2.4	.3				81,022	243	614	340			56	4.1	13.4	760	.2	172.2	168.2		
10.40 p. m.		185,700	65		2.4	.3				83,067	238	624	350			55	4.1	15.5	760	.2	171.8	167.6		
11 p. m.																								
11.15 p. m.	300	190,670	65		2.4	1.2	990,000			85,074	242	624	350			55	4.1	14.3	770	.2	158.0	154.0		
11.20 p. m.		195,800	65		2.4	1.3				87,100	242	624	340			55	4.2	14.9	830	.2	176.2	171.7		
11.40 p. m.		200,690	66		2.5	.4				89,141	238	614	350	0.3	4.0	55	4.2	14.8	800	.2	180.9	175.6		
12 p. m.																								
12.15 a. m.	300	206,750	66		2.4	1.2	992,200			91,157	241	634	400			53	4.2	13.8	820	.2	156.3	151.0		
12.20 a. m.		211,160	66		2.4	.3				93,183	243	624	320			54	4.1	14.3	810	.2	163.9	158.9		
12.40 a. m.		216,210	66		2.4	.4				95,219	241	614	450	.3	4.0	54	4.2	14.8	780	.2	163.9	158.9		
1 a. m.																								
1.15 a. m.	300	221,200	67	22,033	2.4	1.3	994,440			97,255	239	614	410			57	4.2	14.5	850	.2	173.8	169.3		
1.20 a. m.		226,390	67		2.5	1.4				99,297	241	604	320			57	4.2	15.1	800	.2	173.0	168.7		
1.40 a. m.		231,390	67		2.4	1.3				101,319	240	604	380	.3	4.5	59	4.3	15.0	800	.2	169.9	165.9		
2 a. m.																								
2.15 a. m.	300	236,850	67		2.4	.5	996,600			103,355	237	614	480			58	4.3	12.2	990	.2	155.1	151.4		
2.20 a. m.		243,490	66		2.4	.8				105,355	240	619	440			58	4.2	13.4	810	.2	148.0	144.6		
2.40 a. m.		250,430	66		2.4	.9				107,392	240	604	440	.3	5.0	57	4.2	13.9	800	.2	153.9	150.0		
3 a. m.		255,270	66	22,337	2.5	1.3	999,150			109,427	240	624	440			58	4.3	14.9	780	.2	163.9	160.0		
3.20 a. m.																								
3.30 a. m.	300	260,700	66		2.3	1.1				111,459	239	624	380			58	4.3	13.9	880	.2	157.9	154.2		
3.40 a. m.		266,930	66		2.5	1.3				113,496	240	604	380	.3	5.0	58	4.3	15.4	740	.2	163.1	159.3		
4 a. m.		271,060	65		2.4	1.4	1,001,330			115,539	241	624	400			58	4.3	15.8	740	.2	169.0	165.0		
4.20 a. m.																								

January 24.

a January 24.

Log of producer-gas test No. 20, Indian Territory No. 4 coal, January 23, 24, 1905—Continued.

Time.	Coal consumed by producer (pounds).		(gas meter cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manome- ters at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manome- ters at pro- ducer.		Temperatures.				Cubic feet of gas.	B. T. U.	
						1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mer- cury).	Gas leaving (inches wa- ter).	Gas (° F.).	Water (° C.).		Cubic centimeters of water collected.		As read.	Standardized.
																		Inlet.	Outlet.				
10.45 a. m.	300		395, 200	66		2.3	0.6				156, 055	240	624	580			76	4.2	13.3	860	0.2	155.1	156.8
11 a. m.			401, 650	66		2.2	.5	1 016, 900			158, 083	240	624	580			83	4.2	13.7	840	.2	168.3	172.1
11.20 a. m.			408, 650	65		2.1	.2				160, 092	239	476	590			78	4.3	11.4	900	.2	126.6	138.3
11.40 a. m.																							
11.45 a. m.	300																						
12 m.			415, 000	65		2.1	.2				162, 120	240	624	600			75	4.4	13.9	840	.2	138.3	159.6
12.20 p. m.			421, 750	66		2.1	.0	1 019, 000			164, 142	235	624	640			74	4.4	12.2	1, 060	.2	163.9	165.0
12.30 p. m.	300																						
12.40 p. m.			428, 850	65		2.2	.4				166, 157	239	518	540			71	4.4	12.8	780	.2	129.7	129.7
12.50 p. m.	300																						
1 p. m.			434, 000	65		2.5	1.4				168, 197	242	513	550			67	4.4	15.4	750	.2	163.5	162.1
1.20 p. m.			438, 750	65		2.4	1.4	1 021, 300			170, 243	241	466	550	0.4	5.0	65	4.5	15.6	760	.2	167.1	165.4
1.30 p. m.	300																						
1.40 p. m.			443, 550	64		2.4	1.4				172, 274	242	508	440			60	4.3	15.6	720	.2	161.1	158.0
2 p. m.	300		448, 350	63		2.4	1.3				174, 314	241	545	480			60	4.2	14.9	750	.2	159.1	156.1
2.20 p. m.			453, 220	63		2.4	1.4	1 023, 420			176, 354	241	513	480			58	4.2	14.1	770	.2	163.2	149.7
2.40 p. m.	300		458, 200	62		2.4	1.3				178, 387	239	518	500			56	4.0	13.0	800	.2	142.8	138.7
3 p. m.			463, 300	61		2.4	1.2				180, 412	241	518	510			63	4.1	12.5	840	.2	139.8	137.8
3.20 p. m.			469, 050	60	24, 274	2.4	1.3	1 025, 610			182, 432	238	545	560			60	4.2	10.9	910	.2	120.6	118.5

a At 12.30 p. m. the load was reduced to about 500 amperes.

PRODUCER-GAS TESTS.

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GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
10.30 a. m. ^a	5.8	0.2	13.4	8.1	7.1	65.4	100.0	150.6
12.30 p. m.	6.2	.0	11.2	9.0	6.6	67.0	100.0	140.7
2.30 p. m.	5.2	.0	20.4	11.1	6.5	56.8	100.0	179.0
4.30 p. m.	5.2	.6	21.2	12.4	6.9	53.7	100.0	190.7
6.30 p. m.	6.8	.2	21.2	11.5	5.7	54.6	100.0	164.7
8.30 p. m.	7.4	.2	20.6	13.5	6.3	52.0	100.0	185.9
10.30 p. m.	7.8	.0	20.2	12.9	5.2	53.9	100.0	170.8
12.30 a. m.	8.0	.2	18.2	11.2	5.3	57.1	100.0	158.9
2.30 a. m.	10.4	.2	12.2	4.3	7.4	65.5	100.0	136.4
4.30 a. m.	8.0	.2	18.0	12.6	5.9	55.3	100.0	169.5
6.30 a. m.	9.4	.8	17.4	8.1	6.4	57.9	100.0	157.1
8.30 a. m.	11.2	.0	10.6	5.9	3.8	68.5	100.0	98.0
10.30 a. m.	9.8	.2	15.2	9.3	4.7	60.8	100.0	135.5
12.30 p. m.	10.8	.2	13.8	7.4	3.0	64.8	100.0	103.8
2.30 p. m.	9.2	.6	18.4	11.6	3.9	56.3	100.0	146.1

^a January 23.

^b January 24.

Producer-gas test No. 20, Indian Territory No. 4 coal.

[Recorded by W. C. Weidmann and Kurt Toensfeldt, January 23, 24, 1905.]

1. Duration of test, in hours 22.67

AVERAGE TEMPERATURE, °F.

2. Gas leaving producer 686

3-6. (See footnote on p. 1027.)

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

7. Total steam used by producer.....pounds.. 4,645
8. Steam used by producer per hour do.... 205
9. Equivalent in pounds of coal per hour 34.5
10. Equivalent in pounds of dry coal per hour 31.4
11. Equivalent in pounds of combustible per hour..... 25.8
12. Average horsepower required to drive auxiliary machinery..... 11.5
13. Total water used in scrubber and tar extractor cubic feet.. 3,646
14. Cubic feet of water per hour per horsepower of producer plant..... .644
15. Cubic feet of water per 1,000 cubic feet of gas produced 10.3

OPERATIONS OF THE COAL-TESTING PLANT.

COAL CONSUMED IN PRODUCER.

16. Total coal consumed	pounds..	6,300
17. Moisture in coal	per cent..	9
18. Total dry coal consumed	pounds..	5,740
19. Refuse from dry coal	per cent..	17.98
20. Total refuse from coal	pounds..	1,033
21. Total combustible consumed	do....	4,707

COAL PER HOUR.

22. Coal consumed in producer	pounds..	278
23. Dry coal consumed in producer	do....	253.2
24. Combustible consumed in producer	do....	207.8
25. Equivalent coal used by producer plant	do....	312.5
26. Equivalent dry coal used by producer plant	do....	284.6
27. Equivalent combustible used by producer plant	do....	233.6

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired	7.23
29. Dry coal	6.59
30. Combustible	5.40

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired	10,364
32. Per pound of dry coal	11,392
33. Per pound of combustible	13,890
34. From coal as fired, per hour	2,885,000
35. From dry coal, per hour	2,885,000
36. From combustible, per hour	2,885,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total	355,280
38. Per hour	15,680
39. Per pound coal consumed in producer	56.4
40. Per pound dry coal consumed in producer	61.9
41. Per pound combustible consumed in producer	75.5
42. Per pound equivalent coal used by producer plant	50.2
43. Per pound equivalent dry coal used by producer plant	55.1
44. Per pound equivalent combustible used by producer plant	67.1

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot	161.1
46. Per pound dry coal burned in producer	9,980
47. Per hour per brake horsepower	10,750

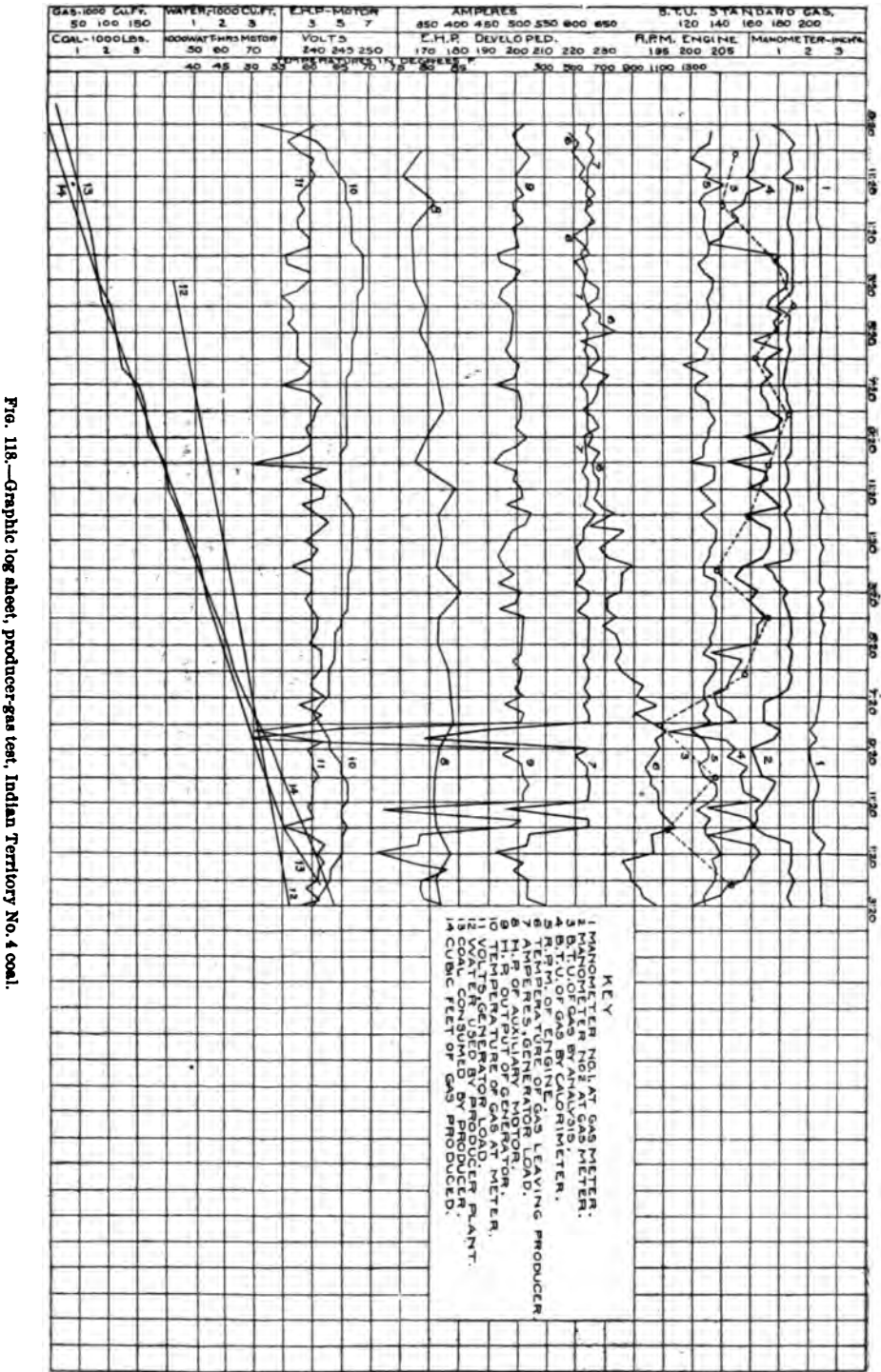


FIG. 118.—Graphic log sheet, producer-gas test, Indian Territory No. 4 coal.

OPERATIONS OF THE COAL-TESTING PLANT.

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	188
49. Electrical horsepower developed at switch board.....	199.5
50. Brake horsepower available for outside purposes.....	221.2
51. Brake horsepower developed at engine.....	234.8

COAL PER HORSEPOWER PER HOUR.

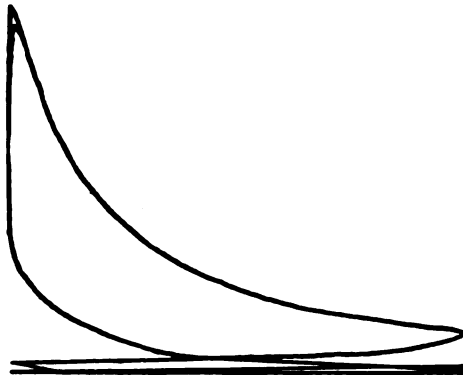
	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	1.48	1.35	1.10
55. Pounds consumed in producer per electrical horsepower developed at switchboard.....	1.39	1.27	1.04
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	1.26	1.15	.94
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	1.18	1.08	.89
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	1.66	1.51	1.24
59. Equivalent pounds used by producer plant per electrical horsepower developed at switchboard.....	1.57	1.43	1.17
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	1.41	1.29	1.06
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	1.33	1.21	1.00

^a Based on an assumed efficiency of 85 per cent for generator and belt.

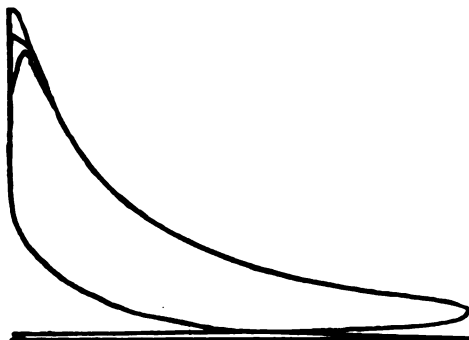
AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	9.00	Carbon dioxide (CO ₂).....	7.29
Volatile matter.....	33.96	Oxygen (O ₂).....	.24
Fixed carbon.....	40.68	Carbon monoxide (CO).....	17.64
Ash.....	16.36	Hydrogen (H ₂).....	10.43
	100.00	Methane (CH ₄).....	6.30
Sulphur.....	4.12	Nitrogen (N ₂).....	58.10
			100.00

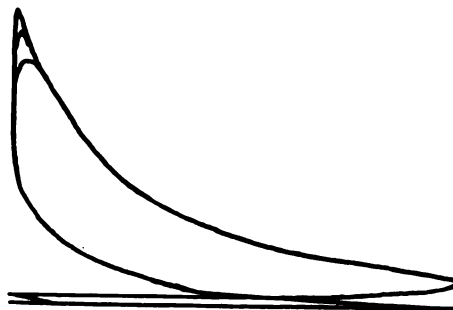
Although rather high in sulphur, this coal burned very well in the producer during the early part of the test, but the character of the fuel seemed to change suddenly to a lower grade, from which no good results could be obtained. After 8.20 a. m. January 24, it was found to be out of the question to carry full load with any degree of regularity. The report includes only that part of the test between 9.40 a. m. January 23 and 8.20 a. m. January 24. No trouble was experienced from clinkers.



Right cylinder. M. E. P., 61; Max. 290; Rel., 29; I. H. P., 96.6.



Center cylinder. M. E. P., 61; Max., 260; Rel., 26; I. H. P., 96.6.



Left cylinder. M. E. P., 48; Max., 240; Rel., 24; I. H. P., 76.8.

Indicator diagrams taken January 23, 1905, during gas-engine test No. 20, on Indian Territory No. 4 coal. Scale of spring, 80; revolutions per minute, 203.

Fifty gallons of black tar were taken from this coal. Although this tar did not look so good as some of that from other coals, yet without analysis it is difficult to determine its exact value.

GAS ENGINE.

Following are results of tests made on the gas engine:

Report of gas-engine test No. 20.

Recorded by K. Toensfeldt and W. C. Weidmann, January 23, 24, 1905.

Producer test No. 20.

Coal: General number, Indian Territory No. 4; special number, G. P. 20. Car initials and number, M., K. and T. 24423.

Duration of test, in hours	23
Revolutions per minute (mean)	203
Explosions per minute (mean)	101.5
Cubic feet gas per hour, by meter	15,480
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure)	15,660
Maximum pressure:	
First cylinder	285.5
Second cylinder	270
Third cylinder	259
Pressure at release:	
First cylinder	26.9
Second cylinder	25.3
Third cylinder	25.5
Mean effective pressure:	
First cylinder	60.8
Second cylinder	58.9
Third cylinder	51.6
Indicated horsepower:	
First cylinder	97.16
Second cylinder	94.16
Third cylinder	82.56
Total indicated horsepower	273.88
Horsepower delivered (electrical horsepower)	199.5
Mechanical efficiency (engine and generator combined)	72.8
Cubic feet standard gas per hour per indicated horsepower	57.2
Cubic feet standard gas per hour per electrical horsepower	78.5

IOWA No. 2.

GENERAL RESULTS.

The general results of tests of Iowa No. 2 coal are shown in the following tables:

Log of producer-gas test No. 22, Iowa No. 2 coal, January 30, 31, 1905.
[Coal from mine No. 6 of the Mammoth Vein Coal Company, Hamilton, Iowa.]

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Temperatures.				Gas calorimeter.		B. T. U.	
				5	6	7	8	9	10	11	12	13	Air entering (inches mercury).		(gas leaving meter).	Gas (° F.).	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.		
1	300		4	5										14	15	16	17	18	19	20	21	22	23	
9.30 a. m. ^a	300	1,001,250	51	47,015	2.0	-0.7	85,100			0,000		242	624	290										
10.05 a. m.		1,007,800	55		2.3	+0.6			2,035			220	624	440	0.4	5.0	52	4.2	10.9	1,020	0.2	135.3	133.8	
10.25 a. m.		1,013,700	54		2.4	+1.0			4,061			230	624	500			52	4.2	11.0	1,120	.2	150.7	148.0	
10.45 a. m.	300	1,020,950	63	47,190	2.2	6	87,000		6,061			231	624	490			56	4.2	10.9	1,120	.2	148.8	147.2	
11.05 a. m.		1,026,700	63		2.2	0			8,076			228	619	490			63	4.6	17.6	450	.2	115.9	116.3	
11.25 a. m.	300	1,032,900	65		2.3	.7			10,119			227	624	440	.45	5.5	64	4.3	12.3	970	.2	154.0	154.8	
11.45 a. m.	300						11,155																	
12.05 p. m.		1,038,750	67	47,365	2.4	1.0	89,150		12,161			238	624	390			64	4.2	13.4	910	.2	165.9	166.7	
12.25 p. m.		1,044,240	68		2.4	1.0			14,202			232	649				69	4.4	13.2	1,020	.2	177.0	179.5	
12.30 p. m.	300																							
12.45 p. m.		1,049,800	69		2.4	1.0						239	624				62	4.3	15.4	720	.2	158.3	158.5	
1.05 p. m.		1,055,500	69	47,519	2.4	1.0	91,490		18,167			238	624	450			62	4.4	13.9	740	.2	139.3	139.5	
1.15 p. m.	300																							
1.25 p. m.		1,061,240	69		2.4	1.0			20,198			240	624	420	.4	5.0	61	4.4	14.5	740	.2	148.0	148.8	
1.45 p. m.		1,066,750	70		2.5	1.2			22,248			240	619	460			68	4.6	15.2	830	.2	174.2	176.4	
2.05 p. m.		1,072,210	70		2.5	1.2	93,480		24,283			238	584	500									(b)	
2.20 p. m.																								
2.25 p. m.	300	1,077,950	71		2.5	1.0			26,277			242	624	510									(b)	
2.45 p. m.		1,083,820	72		2.5	1.0			28,290			228	624	490	.5	5.0							(b)	
3.05 p. m.	300	1,090,150	71	47,859	2.5	.8	95,500		30,282			239	624	490			68	4.5	14.3	760	.2	147.6	149.4	
3.25 p. m.		1,096,000	72		2.5	1.2			32,343			240	604	420			67	4.6	17.5	640	.2	163.5	165.2	
3.45 p. m.		1,101,730	72		2.5	1.0			34,106			241	614	470			67	4.6	17.5	640	.2	163.5	165.2	
4.05 p. m.		1,107,360	73		2.5	1.0	97,520		36,157			240	604	490			66	4.4	17.4	630	.2	162.3	163.8	

^a January 30. Average barometer for entire test, 29.92 inches.

^b Meter connected with calorimeter clogged.

Log of producer-gas test No. 22, Iowa No. 2 coal, January 30, 31, 1905—Continued.

Time.	(Coal consumed by producer (pounds).	Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Gas calorimeter.				B. T. U.			
																		Temperatures.		Cubic centimeters of water collected.				Cubic feet of gas.	
1	2	3	4	5	6	1.	2.	Wall meter.	Ammeter.	1.	2.	Volts.	Amperes.	14	15	16	17	18	19	20	21	22	23		
4.10 p. m.	300	1,113,000	73			2.5	0			38,190		240	619	460			67	4.5	17.3	630	0.2	159.9	161.6		
4.25 p. m.		1,118,720	72			2.5	0			40,227		241	614	460			68	4.5	17.3	630	0.2	159.9	161.8		
4.45 p. m.	300	1,124,350	73	48,203		2.5	0	99,670		42,270		240	614	440	0.3	5.0	68	4.5	17.6	640	0.2	166.3	168.4		
5.05 p. m.		1,130,050	73			2.5	0			44,309		238	624	460			69	4.5	17.6	650	0.2	168.6	171.1		
5.25 p. m.		1,135,730	73			2.4	1.0			46,343		238	624	480			69	4.6	17.6	630	0.2	162.3	164.8		
5.45 p. m.	300	1,141,290	73			2.5		101,750		48,383		241	614	410			71	4.5	17.7	640	0.2	167.4	170.5		
6.05 p. m.		1,146,550	73			2.5				50,448		236	604	420	0.3	4.5	71	4.6	18.0	620	0.2	164.7	167.7		
6.25 p. m.		1,151,920	73			2.4				52,461		240	619	415			72	4.6	17.9	620	0.2	163.5	166.8		
6.45 p. m.	300	1,157,350	74			2.4	1.	103,800		54,475		239	619	490	0.45	6.0	72	4.6	17.7	640	0.2	166.3	169.8		
7.05 p. m.		1,163,100	74			2.4				56,480		238	621	480			70	4.6	16.2	670	0.2	154.3	156.9		
7.25 p. m.		1,169,350	73			2.4				58,519		240	619	510			70	4.5	16.2	660	0.2	153.2	155.7		
7.50 p. m.	300	1,175,750	73			2.4	.8	105,850		60,545		240	619	470			70	4.5	16.6	660	0.2	158.3	160.9		
8.05 p. m.		1,181,800	73			2.4	1.0			62,577		244	619	490			69	4.5	16.7	700	0.2	169.4	171.8		
8.25 p. m.	300	1,187,550	73			2.4	1.0			64,601		238	624	450			70	4.5	16.6	690	0.2	165.5	169.9		
8.45 p. m.		1,193,250	74			2.4	1.0			66,631		241	624	420	0.4	5.0	70	4.5	16.8	700	0.2	169.4	172.2		
9.05 p. m.		1,199,100	74			2.4	1.0			68,631		239	624	500			73	4.6	16.2	710	0.2	165.5	169.3		
9.25 p. m.	300	1,204,950	74			2.4	1.0			70,640		242	624	520			68	4.6	15.0	760	0.2	156.7	158.7		
9.45 p. m.		1,210,900	73			2.4	1.0			72,677		236	624	540			67	4.6	15.0	820	0.2	169.0	170.8		
10.05 p. m.		1,217,000	73			2.4	1.0			71,715		242	624	560			64	4.4	14.6	760	0.2	153.8	154.6		
10.25 p. m.	300	1,223,400	73			2.3	0.5			76,745		240	614	600			66	4.5	13.3	850	0.2	148.4	149.8		

Log of producer-gas test No. 22, Iowa No. 2 coal, January 30, 31, 1905—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manome- ters at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manome- ters at pro- ducer.		Gas calorimeter.				B. T. U.				
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mer- cury).	Gas leaving (inches wa- ter).	Gas (° F.).	Temperatures.		Cubic centimeters of water collected.		Cubic feet of gas.			
																	Inlet.	Outlet.						
																						Water (° C.).		
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.		23.	
11.05 p. m.		1,230,300	73	49,085	2.1	-0.4		111,500		78,754		236	624	620			68	4.6	12.3	1,010	0.2	158.7	160.6	
11.15 p. m.	300																							
11.25 p. m.		1,237,350	73		2.1	.0				80,775		244	624	580			70	4.6	12.7	980	0.2	157.5	160.2	
11.45 p. m.		1,244,300	74		2.1	.0				82,797		240	614	580	0.5	6.5	70	4.6	12.7	1,000	.2	160.7	163.4	
12 p. m.	300																							
12.05 a. m.		1,251,090	73		2.2	+	.3	113,460		84,860		238	614	520			70	4.6	13.8	850	.2	155.1	157.8	
12.25 a. m.		1,257,590	74		2.2	.3				86,894		240	624	550			69	4.5	13.4	960	.2	169.4	171.8	
12.45 a. m.	300	1,264,300	74		2.2	.3				88,930		236	494	620			70	4.5	12.9	950	.2	158.3	160.9	
1.05 a. m.		1,271,410	74		2.2	-	.1	115,290		90,943		239	624	550			70	4.6	12.4	1,090	.2	168.6	171.4	
1.15 a. m.	300																							
1.25 a. m.		1,278,760	74		2.2	-	.3			92,938		235	508	620	.3	6.0	70	4.6	11.3	1,090	.2	144.8	147.2	
1.45 a. m.	300	1,285,920	74		2.0	-	.1			94,964		237	518	580			70	4.6	12.1	1,000	.2	148.8	151.3	
2.05 a. m.	300	1,292,750	74		2.2	+	.2	117,200		97,006		239	518	500	.4	6.0	70	4.4	13.3	880	.2	155.1	157.7	
2.25 a. m.		1,299,390	74		2.2	.2				99,047		237	614	490			70	4.6	13.2	950	.2	161.9	164.5	
2.45 a. m.	300	1,306,030	74		2.3	.3				101,065		241	604	450	.4	6.0	70	4.4	13.2	950	.2	166.8	168.5	
3.05 a. m.		1,312,790	74	49,640	2.2	.1		118,980		103,082		241	560	450			70	4.5	12.6	990	.2	159.1	161.7	
3.25 a. m.		1,320,800	73		2.2	-	.1			105,040		232	493	520			69	4.5	11.0	1,070	.2	138.0	140.0	
3.30 a. m.	300																							
3.45 a. m.		1,326,590	73		2.3	+	.3			107,081		233	466	490			69	4.4	13.2	850	.2	148.4	150.5	
4.05 a. m.		1,333,200	73		2.2	.1				109,085		233	404	640			68	4.6	12.0	970	.2	142.4	144.1	
4.15 a. m.	300																						(b)	
4.25 a. m.		1,340,480	73		2.2	-	.4			111,030		239	466	600										
4.45 a. m.		1,347,600	73		2.4	+	.3			113,072		234	404	700			68	4.4	12.4	860	.2	136.5	137.2	
5 a. m.	300																							
5.05 a. m.		1,354,600	73		2.4	.8				115,116		248	374	530			68	4.4	13.3	720	.2	127.0	128.6	
5.25 a. m.		1,361,000	72		2.3	.8				117,161		244	374	510			68	4.4	15.4	710	.2	154.7	156.6	

^a January 31.

^b Calorimeter reading lost.

Log of producer-gas test No. 22, Iowa No. 2 coal, January 30, 31, 1905—Continued.

Time.	Coal consumed by producer (pounds).	Gas calorimeter.																							
		Gas meter (cubic feet).		Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.	Manometers at producer.				Temperatures.			Cubic feet of gas.			B. T. U.		
						1.	2.	Watt meter.	Ammeter.	1.	2.		Volts.	Ampers.	Temperature of gas leaving producer (° C.).	Air entering (inches mercury).	Gas leaving (inches water).	Gas (° F.).	Water (° C.).						
																			Inlet.						Outlet.
5.45 a. m.	300	1,367,490	72	50,064	2.3	0.8				119,183		232	454	610			68	4.4	14.5	730	0.2	146.0	147.8		
6.05 a. m.		1,373,100	71		2.3	.7	124,100			121,212		236	466	580			67	4.5	15.4	700	.2	151.1	152.7		
6.25 a. m.		1,380,400	72		2.3	.8				123,222		230	466	570			68	4.1	14.7	740	.2	151.1	152.8		
6.30 a. m.	300																								
6.45 a. m.		1,387,700	72		2.3	.8				125,227		236	476	470			67	4.4	15.3	730	.2	156.3	157.9		
7.05 a. m.		1,394,525	72		2.3	.0				127,227		230	476	580			68	4.5	14.5	740	.2	146.8	148.6		
7.25 a. m.		1,401,350	72		2.3	.0				129,197		224	466	660			66	4.5	12.7	890	.2	144.8	146.3		
7.30 a. m.	300																								
7.45 a. m.		1,408,900	72		2.1	.5				131,300		226	414	620			65	4.7	10.7	950	.2	113.1	113.8		
8.05 a. m.	300	1,416,600	72	50,317	2.2	-1.0	127,490			133,198		242	324	660									(a)		
8.25 a. m.		1,424,300	72		2.2	-1.0				135,204		238	294	700			65	4.5	10.3	950	.2	109.1	109.8		
8.45 a. m.		1,431,850	73		2.2	-1.0				137,198		236	518	540			66	4.5	11.7	1,020	.2	145.6	147.0		
9.05 a. m.		1,439,250	75		2.1	-1.0	129,100			139,171		234	476	660		.5	6.0	4.5	11.4	1,040	.2	142.4	143.8		
9.15 a. m.	300																								
9.25 a. m.		1,446,500	76		2.1	-.8				141,177		235	304	610			67	4.6	13.0	860	.2	143.2	144.7		
9.45 a. m.		1,453,650	76		2.0	-.7				143,165		248	314	690		.65	7.5	4.6	9.7	1,000	.2	99.2	100.1		
9.55 a. m.	300																								
10.05 a. m.		1,460,850	77	50,620	2.0	-.6	130,900			145,204		242	424	630			66	4.6	12.8	840	.2	136.5	137.7		
10.25 a. m.	300	1,467,650	78		2.1	-.2				145,144		256	344	660			68	4.5	13.0	830	.2	139.7	141.5		
10.45 a. m.		1,473,800	78		2.3	+.8				147,192		246	354	640		.65	7.5	4.6	13.2	800	.2	136.5	138.2		
11.05 a. m.		1,479,950	77	50,770	2.3	+.6	132,600			149,229		251	314	680			69	4.7	13.1	790	.2	131.3	133.2		

a Flame of calorimeter burner went out.

PRODUCER-GAS TESTS.

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GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
10.30 a. m. ^a	9.4	0.0	12.6	7.8	5.6	64.6	100.0	127.8
12.30 p. m.	10.6	.2	11.2	22.1	8.2	47.7	100.0	199.3
2.30 p. m.	10.4	.2	12.0	6.8	6.8	63.8	100.0	138.0
4.30 p. m.	9.8	.2	12.6	12.0	7.4	58.0	100.0	164.5
6.30 p. m.	10.2	.2	13.0	6.7	9.2	60.7	100.0	166.7
8.30 p. m.	9.6	.2	13.6	5.8	9.2	61.6	100.0	165.6
10.30 p. m.	10.4	.2	13.0	5.5	7.3	63.6	100.0	142.3
12.30 a. m. ^b	11.0	.0	11.2	6.5	6.8	64.5	100.0	134.1
2.30 a. m.	11.8	.0	8.4	4.9	8.9	66.0	100.0	141.2
4.30 a. m.	13.0	.0	6.2	3.9	7.8	69.1	100.0	118.3
6.30 a. m.	12.0	.0	9.8	5.6	8.8	63.8	100.0	147.2
8.30 a. m.	13.4	.4	9.8	3.8	.0	72.6	100.0	117.6

^a January 30.

^b January 31.

Producer-gas test No. 22, Iowa No. 2 coal.

[Recorded by W. C. Weldmann and Kurt Toensfeldt, January 30, 31, 1906.]

1. Duration of test, in hours..... 13.33

AVERAGE TEMPERATURE, ° F.

2. Gas leaving producer..... 893

3-6. (See footnote on p. 1027.)

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

7. Total steam used by producer pounds.. 3,065
8. Steam used by producer per hour do.... 230
9. Equivalent in pounds of coal per hour 45.9
10. Equivalent in pounds of dry coal per hour 38.2
11. Equivalent in pounds of combustible per hour 28.7
12. Average horsepower required to drive auxiliary machinery 10.9
13. Total water used in scrubber and tar extractor cubic feet.. 2,133
14. Cubic feet of water per hour per horsepower of producer plant 64
15. Cubic feet of water per 1,000 cubic feet of gas produced 9.12

COAL CONSUMED IN PRODUCER.

16. Total coal consumed pounds.. 4,833
17. Moisture in coal per cent.. 16.69
18. Total dry coal consumed pounds.. 4,030
19. Refuse from dry coal per cent.. 24.85
20. Total refuse from coal pounds.. 1,000
21. Total combustible consumed.....do.... 3,030

OPERATIONS OF THE COAL-TESTING PLANT.

COAL PER HOUR.

22. Coal consumed in producer	pounds..	362.5
23. Dry coal consumed in producer	do....	302.5
24. Combustible consumed in producer	do....	227.5
25. Equivalent coal used by producer plant	do....	408.4
26. Equivalent dry coal used by producer plant.....	do....	340.7
27. Equivalent combustible used by producer plant.....	do....	256.2

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired	9.43
29. Dry coal	7.87
30. Combustible	5.92

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired	8,735
32. Per pound of dry coal	10,489
33. Per pound of combustible.....	13,950
34. From coal as fired, per hour	3,175,000
35. From dry coal, per hour	3,175,000
36. From combustible, per hour	3,175,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total	234,110
38. Per hour	17,570
39. Per pound coal consumed in producer	48.5
40. Per pound dry coal consumed in producer	58.1
41. Per pound combustible consumed in producer.....	77.2
42. Per pound equivalent coal used by producer plant.....	43
43. Per pound equivalent dry coal used by producer plant.....	51.6
44. Per pound equivalent combustible used by producer plant	68.5

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot	160.2
46. Per pound dry coal burned in producer.....	9,300
47. Per hour per brake horsepower	12,130

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes	186.6
49. Electrical horsepower developed at switch board	197.5
50. Brake horsepower available for outside purposes	219.5
51. Brake horsepower developed at engine	232.3

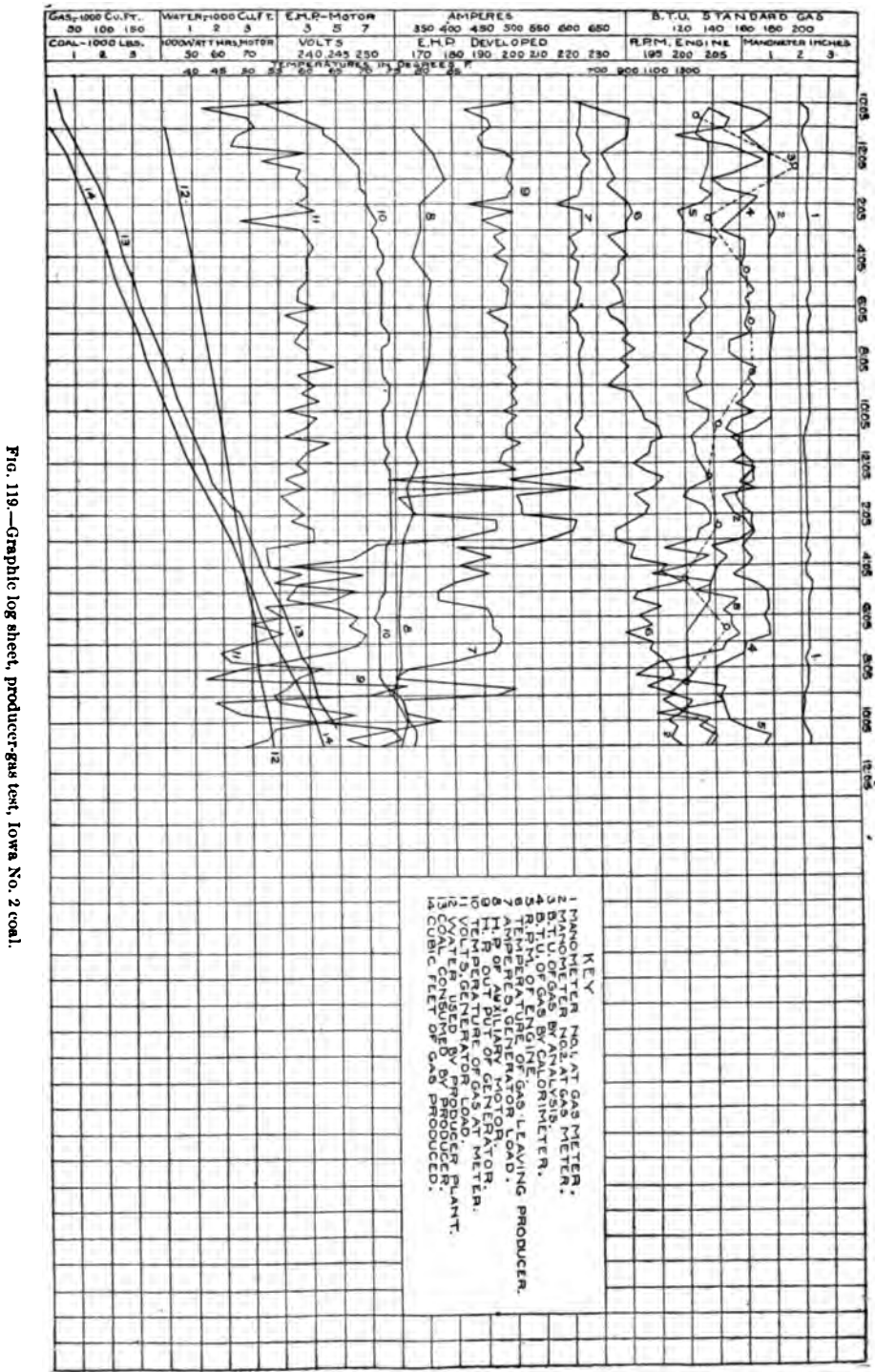


FIG. 119.—Graphical log sheet, producer-gas test, Iowa No. 2 coal.

OPERATIONS OF THE COAL-TESTING PLANT.

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes	1.94	1.62	1.22
55. Pounds consumed in producer per electrical horsepower developed at switch board	1.84	1.53	1.15
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes	1.65	1.38	1.04
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	1.56	1.30	.98
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	2.19	1.83	1.37
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board	2.07	1.73	1.30
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	1.86	1.55	1.17
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	1.76	1.47	1.10

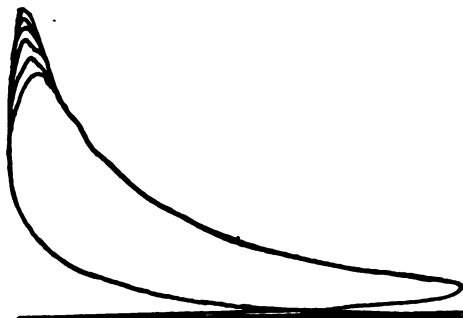
^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture	16.69	Carbon dioxide (CO ₂)	10.06
Volatile matter.....	31.42	Oxygen (O ₂)	.17
Fixed carbon.....	31.19	Carbon monoxide (CO)	12.57
Ash.....	20.70	Hydrogen (H ₂)	9.53
	100.00	Methane (CH ₄)	7.67
Sulphur.....	5.50	Nitrogen (N ₂)	60.00
			100.00

This coal was very high in sulphur (5.50 per cent), but did not clinker in the producer. The results were, however, not so satisfactory as might be expected. There is no doubt that better records can be made from this coal in a second test. The lack of uniformity in the gas made it difficult to adjust the engine to meet the changes.

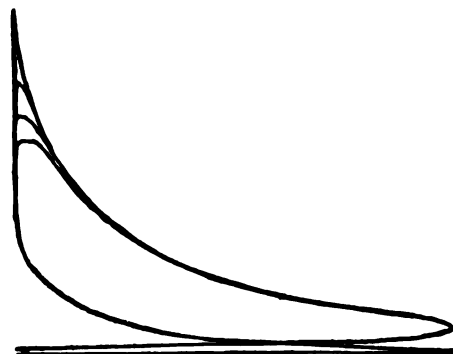
Fifty gallons of black tar were extracted.



Right cylinder. M. E. P., 58; Max., 260; Rel., 24; I. H. P., 63.2.



Center cylinder. M. E. P., 59; Max., 270; Rel., 26; I. H. P., 64.8.



Left cylinder. M. E. P., 50; Max., 290; Rel., 24; I. H. P., 50.3.

Indicator diagrams taken January 30, 1905, during gas-engine test No. 22, on Iowa No. 2 coal. Revolutions per minute, 204.1.

GAS ENGINE.

The report covers the records taken from 10.45 a. m. January 30 to 12.05 a. m. January 31, a period of 13.33 hours. After 12.05 a. m. January 31 it was impossible to carry full load on the engine.

The result of tests made on the gas engine are given below.

Report of gas-engine test No 22.

Recorded by W. C. Weidmann and Kurt Toensfeldt, January 30 and 31, 1905.

Producer test No. 22.

Coal: General number, Iowa No. 2; special number, G. P. 22. Car initials and number, 43574, Wabash.

Duration of test, in hours.....	13½
Revolutions per minute (mean).....	202.7
Explosions per minute (mean).....	101.35
Cubic feet gas per hour, by meter	17,820
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	17,560
Maximum pressure:	
First cylinder	272
Second cylinder	282
Third cylinder.....	272
Pressure at release:	
First cylinder	24
Second cylinder	26
Third cylinder.....	24
Mean effective pressure:	
First cylinder	58
Second cylinder	59
Third cylinder	54
Indicated horsepower:	
First cylinder.....	93
Second cylinder	95
Third cylinder.....	87.05
Total indicated horsepower	275.05
Horsepower delivered (electrical horsepower).....	197.5
Mechanical efficiency (engine and generator combined)	71.8 per cent..
Cubic feet standard gas per hour per indicated horsepower	63.9
Cubic feet standard gas per hour per electrical horsepower.....	88.9

KANSAS No. 5.

GENERAL RESULTS.

Following are tables showing the general results of tests of Kansas No. 5 coal:

Log of producer-gas test No. 24, Kansas No. 5 coal, February 6, 7, 1905.
[Coal from mine No. 11 of the Southwestern Development Company, West Mineral, Kans.]

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).	Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Temperatures (° C.).				Cubic feet of gas.		Cubic centimeters of water collected.		B. T. U.	
		1.	2.				Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Outlet.	Water.	As read.	Standardized.				
1		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23			
2.40 p. m. ^a		66,600	67		2.0		194,450		0,000		239	634		0.5	5.0								(b)		
3 p. m.		74,000	67		2.0				2,004		240	518											(b)		
3.05 p. m.	300																						(b)		
3.20 p. m.		81,400	67		2.2				3,984		239	624											(b)		
3.37 p. m.	300																						(b)		
3.40 p. m.		88,560	67		2.3		200,050		6,003		238	624											(b)		
4 p. m.		95,300	66		2.3				8,031		239	614				18.0	4.0	9.1		880	0.1	177.7	179.2		
4.20 p. m.		102,000	66		2.3				10,060		239	634	500			18.0	4.0	9.0		700	.1	138.8	138.9		
4.30 p. m.	300																								
4.40 p. m.		108,700	65		2.3		201,570		12,090		239	614	430			17.0	4.1	9.5		840	.1	179.8	180.7		
5 p. m.		115,300	65		2.4	0.8			14,118		239	644	460			17.0	4.2	8.3		940	.1	146.8	147.6		
5.20 p. m.		121,700	63		2.3	.8			16,148		242	624	460												
5.30 p. m.	300																								
5.40 p. m.		127,890	63		2.3	.8	203,030		18,182		242	624	400	.3	6.5	15.0	4.0	10.2		650	.1	159.9	160.1		
6 p. m.		133,960	63		2.3	.8			20,215		242	614	420			15.0	4.0	10.0		750	.1	178.5	177.8		
6.20 p. m.		139,980	63		2.3	.7			22,248		240	644	400			15.0	4.0	10.4		660	.1	163.5	162.8		
6.30 p. m.	300																								
6.40 p. m.		146,040	63		2.4	.8	204,400		24,278		241	634	410			14.5	4.1	10.5		680	.1	172.6	171.8		
7 p. m.		152,020	63		2.4	.8			26,308		240	624	400			15.0	4.1	10.8		670	.1	178.1	177.4		
7.15 p. m.	300																								
7.20 p. m.		157,850	63		2.4	.9			28,346		240	624	420	.4	6.0	13.0	4.1	10.4		710	.1	177.4	177.2		
7.40 p. m.		163,850	63		2.4	.9			30,376		240	624	400			13.0	4.1	9.9		770	.1	177.4	177.2		
8 p. m.		169,700	64		2.4	.9			32,415		240	624	460			12.5	4.0	9.6		850	.1	188.8	186.8		
8.15 p. m.	300																								

^a February 6. Average barometer for entire test, 29.83 inches.

^b Calorimeter readings omitted. Chemist unavoidably detained until 4 p.m.

Log of producer-gas test No. 24, Kansas No. 5 coal, February 6, 7, 1905—Continued.

Time.	(Coal consumed by producer (pounds).	(Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.	Load.		Manometers at producer.				Temperatures (° C.).				Gas calorimeter.				B. T. U.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
					1.	2.	Watt meter.	Ammeter.		1.	2.	Volts.	Amperes.	Temperature of gas leaving producer (° C.).	Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Water.		Cubic centimeters of water collected.	Cubic feet of gas.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	As read.			Standardized.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
8.20 p. m.		175,710	64		2.4	0.9				34,443	240	624	490				12.0	4.0	9.1	930	0.1	188.0	185.5																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

a February 7.

Log of producer-gas test No. 24, Kansas No. 5 coal, February 6, 7, 1905—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of Gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Manometers at producer.		Gas calorimeter.				B. T. U.			
				1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	Temperature of gas leaving producer (° C.).	Air entering (inches mercury).	Gas leaving (inches water).	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
2.40 a. m.		292,080	62		2.4	0.5	216,340		73,082		238	590	520				12.0	4.0	9.3	740	0.1	155.5	153.4
3 a. m.		298,300	62		2.3	.8			75,061		241	609	400										(a)
3.20 a. m.		304,710	62		2.3	.5			77,087		240	614	620				12.0	3.9	9.9	670	.1	159.5	157.3
3.30 a. m.	300																						
3.40 a. m.		311,040	62		2.2	.5	217,890		79,113		239	634	500				11.5	4.0	10.2	660	.1	162.3	160.0
4 a. m.		317,140	62		2.3	.8			81,146		241	624	440				12.0	4.0	11.1	600	.1	169.0	166.8
4.20 a. m.		323,100	62		2.3	.8			83,181		241	594	400				12.0	4.0	10.9	590	.1	161.5	159.3
4.30 a. m.	300																						
4.40 a. m.		329,100	62		2.3	.8	219,370		85,217		240	634	450				11.5	4.0	10.6	610	.1	159.9	157.6
5 a. m. b.		335,000	62		2.3	.8			87,253		242	604	420				11.5	4.0	11.2	600	.1	171.3	168.8

^a Calorimeter burner out of order.

^b 6.10 a. m. Short circuit in rheostat stopped the engine.

PRODUCER-GAS TESTS.

OPERATIONS OF THE COAL-TESTING PLANT.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
3.30 p. m. ^a	9.0	0.2	11.2	6.0	8.9	64.7	100.0	154.7
5.30 p. m.	10.0	.2	12.0	13.7	7.5	56.6	100.0	169.4
7.30 p. m.	10.0	.4	14.4	10.8	6.6	57.8	100.0	158.0
9.30 p. m.	10.4	.0	13.0	5.5	7.4	63.7	100.0	143.3
11.30 p. m.	10.2	.2	12.2	11.8	6.8	58.8	100.0	156.1
1.30 a. m. ^b	10.8	.0	11.4	7.5	6.8	63.5	100.0	138.3
3.30 a. m.	10.2	.0	11.4	5.0	9.4	64.0	100.0	157.1

^a February 6.

^b February 7.

Producer-gas test No. 24, Kansas No. 5 coal.

[Recorded by W. C. Weldmann and Kurt Toensfeldt, February 6 and 7, 1905.]

1. Duration of test, in hours 13

AVERAGE TEMPERATURE, ° F.

2. Gas leaving producer 840

3-6. (See footnote on p. 1027.)

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

7. Total steam used by producer pounds.. 2,795
8. Steam used by producer per hour do... 215
9. Equivalent in. pounds of coal per hour 30.6
10. Equivalent in pounds of dry coal per hour 29.3
11. Equivalent in pounds of combustible per hour 25.9
12. Average horsepower required to drive auxiliary machinery 8

COAL CONSUMED IN PRODUCER.

16. Total coal consumed pounds.. 4,000
17. Moisture in coal per cent.. 4.35
18. Total dry coal consumed pounds.. 3,825
19. Refuse from dry coal.....per cent.. 11.75
20. Total refuse from coal.....pounds.. 449.5
21. Total combustible consumed.....do... 3,375.3

COAL PER HOUR.

22. Coal consumed in producer.....pounds.. 307.8
23. Dry coal consumed in producer do... 294.3
24. Combustible consumed in producer do... 259.8
25. Equivalent coal used by producer plant do... 338.4
26. Equivalent dry coal used by producer plant do... 323.6
27. Equivalent combustible used by producer plant.....do... 285.7

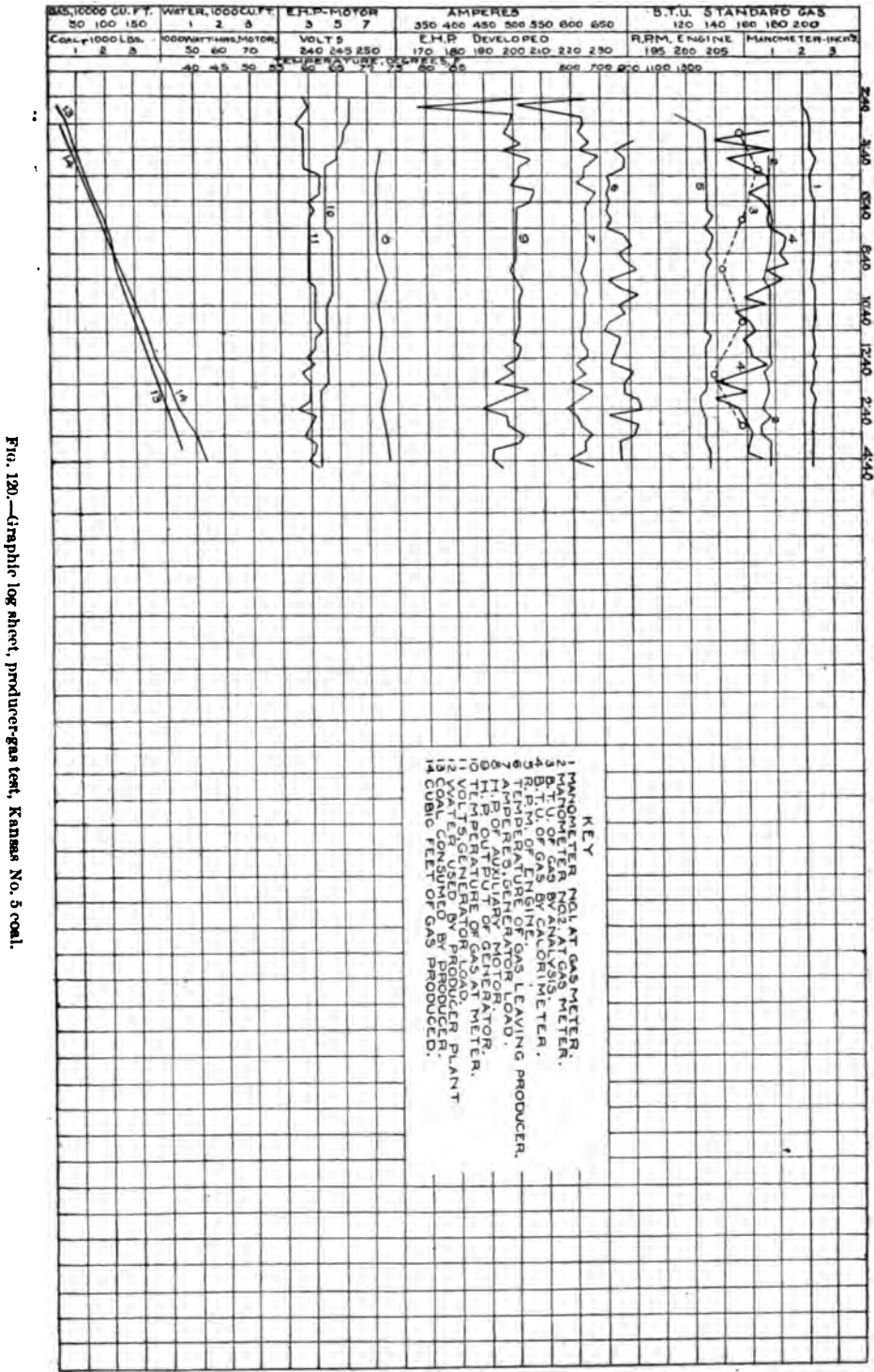


FIG. 120.—Graphical log sheet, producer-gas test, Kansas No. 3 coal.

OPERATIONS OF THE COAL-TESTING PLANT.

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired	8
29. Dry coal	7.65
30. Combustible	6.77

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired	12,836
32. Per pound of dry coal	13,421
33. Per pound of combustible	15,200
34. From coal as fired, per hour	3,950,000
35. From dry coal, per hour	3,950,000
36. From combustible, per hour	3,950,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total	240,310
38. Per hour	18,490
39. Per pound coal consumed in producer	60.1
40. Per pound dry coal consumed in producer	62.8
41. Per pound combustible consumed in producer	71.2
42. Per pound equivalent coal used by producer plant	54.6
43. Per pound equivalent dry coal used by producer plant	57.2
44. Per pound equivalent combustible used by producer plant	64.8

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot	167.2
46. Per pound dry coal burned in producer	10,500
47. Per hour per brake horsepower	13,130

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes	192.2
49. Electrical horsepower developed at switch board	200.2
50. Brake horsepower available for outside purposes	226.1
51. Brake horsepower developed at engine	235.5

EFFICIENCIES.

52. Of conversion and cleaning gas	.782
53. Of producer plant	.709

PRODUCER-GAS TESTS.

1139

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes	1.60	1.53	1.35
55. Pounds consumed in producer per electrical horsepower developed at switch board	1.54	1.47	1.30
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes	1.36	1.30	1.15
57. Pounds consumed in producer per brake horsepower ^a developed at engine	1.31	1.25	1.10
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	1.76	1.68	1.49
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board	1.69	1.62	1.43
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes	1.50	1.43	1.26
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine	1.44	1.37	1.21

^a Based on an assumed efficiency of 85 per cent for generator and belt.

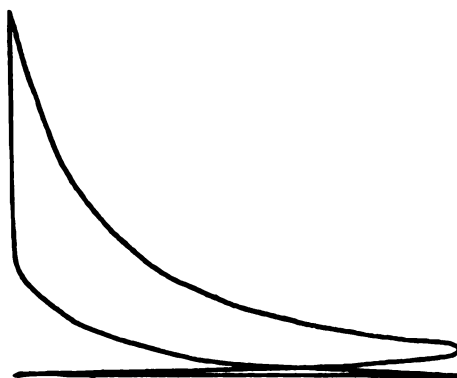
AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture	4.35	Carbon dioxide (CO ₂)	10.27
Volatile matter	31.97	Oxygen (O ₂)	.13
Fixed carbon	52.43	Carbon monoxide (CO)	12.40
Ash	11.25	Hydrogen (H ₂)	9.05
	100.00	Methane (CH ₄)	7.42
Sulphur	3.00	Nitrogen (N ₂)	60.73
			100.00

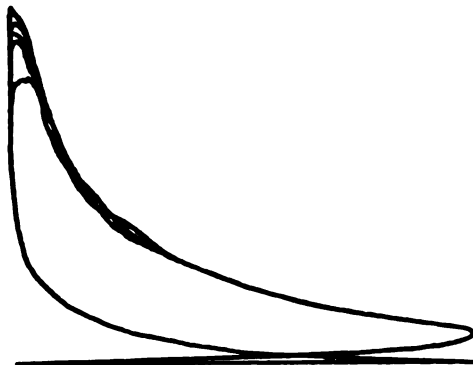
This coal was fed into the producer in the form of a fine slack, and consequently it was difficult to handle with the automatic feeding device in use. It is, however, a fairly good producer fuel.

GAS ENGINE.

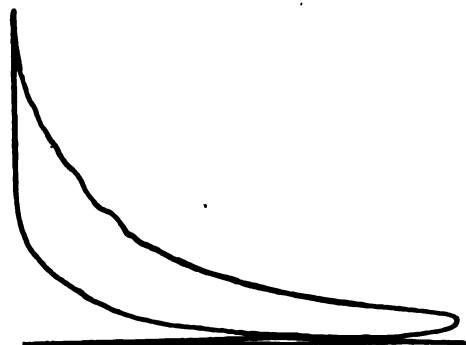
Some trouble was experienced in getting the proper ignition setting for the engine, but after this was secured the run was very satisfactory until interrupted by a short circuit in the rheostat.



Right cylinder. M. E. P., 58; Max., 300; Rel., 24; I. H. P., 63.



Center cylinder. M. E. P., 60; Max., 300; Rel., 28; I. H. P., 66.2



Left cylinder. M. E. P., 46; Max., 280; Rel., 20; I. H. P., 73.2

Indicator diagrams taken February 6, 1905, during gas-engine test No. 24, on Kansas No. 5 coal. Scale of spring, 80; revolutions per minute, 203.5.

The ignition setting was a trifle early, according to the cards shown.

The report is based on the records from 3.40 a. m. February 6 to 4.40 a. m. February 7, a period of thirteen hours.

Tests made on the gas engine are reported in the following table:

Report of gas-engine test No. 24.

Recorded by W. C. Weidmann and K. Toensfeldt, February 6 and 7, 1905.	
Producer test No. 24.	
Coal: General number, Kansas No. 5; special number, G. P. 24. Car initials and number, M., K. and T. 24834.	
Duration of test, in hours.....	13
Revolutions per minute (mean)	203.1
Explosions per minute (mean).....	101.55
Cubic feet gas per hour, by meter	18,500
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	18,480
Maximum pressure:	
First cylinder.....	280
Second cylinder.....	317
Third cylinder.....	303
Pressure at release:	
First cylinder.....	23
Second cylinder.....	26
Third cylinder.....	21
Mean effective pressure:	
First cylinder.....	53
Second cylinder.....	58
Third cylinder.....	48
Indicated horsepower:	
First cylinder.....	85.3
Second cylinder.....	93.33
Third cylinder.....	76.76
Total indicated horsepower	255.39
Horsepower delivered (electrical horsepower)	200.2
Mechanical efficiency (engine and generator combined)..... per cent..	78.4
Cubic feet standard gas per hour per indicated horsepower.....	72.4
Cubic feet standard gas per hour per electrical horsepower.....	92.4

KENTUCKY No. 3.

GENERAL RESULTS.

The general results of tests of Kentucky No. 3 coal are tabulated below.

Log of producer-gas test No. 12, Kentucky No. 3 coal, November 25, 26, 1904.
 [Coal from Barnsley mine of the St. Bernard Mining Company, near Earlington, Ky.]

Time.	(Coal consumed by producer (pounds).	(Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).		Manometer at gas meter (inches water).		Auxiliary motor.		Speed counter on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometer at producer (inches water).		Temperatures (° C.).		Gas calorimeter.		B. T. U.	
				1.	2.	1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	14.	15.	16.	17.	Inlet.	Outlet.	Cubic centimeters of water collected.	(Cubic feet of gas.	As read.	Standardized.
8 a. m. a.	300																						
8.10 a. m.		6,077,870	46.0	109,795	2.0	0.1	421,400			82,756		241	634										
8.30 a. m.		6,084,300	50.0		2.4	+.6				84,787		239	634										
8.50 a. m.		6,090,000	53.0		2.4	+.8				86,815		239	614			0.4	4.5						
9 a. m.	300																20.0	11.00	17.00	1,280	0.2	146.4	147.8
9.10 a. m.		6,095,390	55.0		2.4	.9	423,400			88,844		239	619										
9.30 a. m.		6,101,760	57.0		2.3	.4				90,879		242	624				22.0	11.20	17.00	1,310	.2	150.3	159.3
9.40 a. m.		6,107,850	59.0		2.4	.7				92,913		240	624				24.0	11.35	17.84	1,210	.2	155.5	160.6
9.50 a. m.	300																26.0	11.50	18.30	1,120	.2	150.7	156.8
10 a. m.		6,113,700	61.0	110,100	2.4	.6	425,600			94,274		240	634				25.0	11.58	18.90	1,000	.2	145.2	150.5
10.20 a. m.		6,119,690	62.0		2.4	.6				96,305		239	629										
10.40 a. m.																	29.5	11.40	18.00	1,250	.2	160.4	168.8
10.45 a. m.	300																						
10.50 a. m.		6,125,540	63.0		2.4	.6				98,339	42,599	240	624				30.0	11.60	17.90	1,320	.2	162.3	171.1
11 a. m.		6,131,500	64.5		2.4	.4	427,650			96.0		44,616	239	624			30.5	11.65	18.30	1,250	.2	164.7	173.9
11.10 a. m.		6,137,500	65.5		2.4	.2				98.0		46,644	241	634		3	3.5						
11.30 a. m.																	30.0	11.60	18.12	1,350	.2	156.7	165.2
11.40 a. m.	300																						
11.45 a. m.		6,143,700	66.0		2.4	.6				98.0	48,662	241	629										
11.50 a. m.																							

^a November 26. 8.10 a. m. to 5.50 p. m., barometer 23.73 inches; 5.50 p. m. to end of test, barometer 29.95 inches.

Log of producer-gas test No. 12, Kentucky No. 3 coal, November 25, 26, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.			Temperatures (° C.).					Cubic feet of gas.	As read.	Standardized.
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Water.		Cubic centimeters of water collected.					
																	Inlet.	Outlet.						
1	2	3	4	5	6	7	8	9.	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
12 m.		6,150,000	66.0	110,373	2.4	0.4	429,540	26.0		50,678	239	629				28.0	11.50	17.50	1,420	0.2	169.0	177.8		
12.10 p. m.																								
12.20 p. m.		6,156,000	66.0		2.4	.4		25.0		52,693	241	634				27.0	11.50	17.40	1,400	.2	166.6	174.0		
12.30 p. m.																								
12.45 p. m.	300																							
12.50 p. m.		6,162,190	66.5		2.4	.4		32.5		54,712	242	629				28.0	11.50	17.50	1,420	0.2	169.0	177.8		
12.55 p. m.																								
1.10 p. m.		6,168,100	66.5		2.4	.5	431,430	31.0		(σ)	240	624				25.0	11.40	17.40	1,380	.2	164.2	170.1		
1.30 p. m.		6,174,150	67.0		2.4	.4		24.5		(σ)	240	619												
1.45 p. m.	300																							
1.50 p. m.		6,180,310	66.5		2.4	.4		31.0		59,892	240	629				.3	8.0							
2.10 p. m.		6,186,450	66.5		2.4	.5	433,315	29.0		61,916	241	624												
2.30 p. m.		6,192,780	66.5		2.3	.3		31.0		63,929	241	634												
2.45 p. m.	300																							
2.50 p. m.		6,198,280	66.0		2.3	.4		31.0		65,942	242	629				.4	8.0							
3.05 p. m.																								
3.10 p. m.		6,205,960	65.5		2.3	.3	435,200	25.0		67,961	241	624				21.5	11.00	15.80	1,700	.2	162.0	166.0		
3.15 p. m.																								
3.30 p. m.	300	6,212,710	65.0		2.3	.2		32.0		69,982	242	624				22.0	11.00	15.85	1,750	.2	169.2	173.7		
3.50 p. m.		6,219,070	65.0		2.3	.2		25.5		72,011	242	614				21.8	11.00	15.80	1,820	.2	173.0	176.7		
4 p. m.																								
4.10 p. m.		6,225,530	65.0	110,901	2.3	.0	437,000	31.0		74,040	240	624				21.5	11.10	15.90	1,800	.2	171.3	175.6		
4.15 p. m.	300																							
4.30 p. m.		6,232,770	65.0		2.3	.5		28.0		76,060	242	624				21.5	11.00	16.00	1,400	.2	166.7	172.3		
4.45 p. m.																								

^a Both speed counters out of order from 1.10 to 1.50. Readings of the hand counter were: 1.10 p. m., 204 revolutions; 1.30 p. m., 204 revolutions; 1.50 p. m., 204 revolutions.

Log of producer-gas test No. 12, Kentucky No. 3 coal, November 25, 26, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Temperature of gas (° F.).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Temperatures (° C.).				Gas calorimeter.			
			1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	B. T. U.		
																			As read.	Standardized.	
4.50 p. m.		65.0	2.3	0.2		30.0		78,083	241	619											
5.05 p. m.		64.5	2.3	.4	439,050	33.0		80,105	242	634				21.0	11.00	15.80	1,510	0.2	142.1	145.3	
5.10 p. m.	300											0.5	5.0								
5.15 p. m.																					
5.25 p. m.		63.5	2.3	.4		28.0		82,108	241	624				22.0	11.00	15.80	1,800	.2	171.4	175.8	
5.30 p. m.																					
5.45 p. m.		63.5	2.3	.4		32.0		84,134	243	629				20.5	10.90	15.10	1,910	.2	159.1	162.5	
5.50 p. m.	300																				
6.05 p. m.																					
6.10 p. m.		63.5	2.3	.0	441,100	26.0		86,160	241	614				20.5	10.95	17.05	1,200	.2	145.2	148.3	
6.25 p. m.																					
6.30 p. m.		64.0	2.3	.4		30.0		88,168	240	619				20.0	11.00	16.80	1,300	.2	149.6	152.3	
6.50 p. m.	300	64.0	2.3	.6		32.0		90,189	242	619											
7 p. m.																					
7.10 p. m.		65.0	2.3	.6	443,100	26.0		92,222	240	624				19.5	10.90	16.50	1,550	.2	172.2	175.2	
7.20 p. m.																					
7.30 p. m.		64.5	2.3	.0		31.0		94,243	236	624				19.0	10.90	15.80	1,680	.2	177.1	180.0	
7.40 p. m.	300													19.0	10.90	15.70	1,620	.2	157.1	160.1	
7.45 p. m.																					
7.50 p. m.		63.5	2.3	.4		30.0		96,255	241	624				18.0	10.80	18.50	1,150	.2	175.2	177.4	
8 p. m.																					
8.10 p. m.	300	63.0	2.3	.3	445,020	34.0		98,280	240	624				18.0	10.80	17.20	1,150	.2	146.0	147.9	
8.30 p. m.		63.0												18.0	10.80	16.35	1,220	.2	153.3	155.4	
8.30 p. m.		63.0	2.3	.0		27.5		300	240	624				18.0	10.80	16.35	1,220	.2	153.3	155.4	
8.40 p. m.																					

^a Both speed counters out of order from 8.50 to 9.50. Readings of the hand counter were: 8.50 p. m., 200 revolutions; 9.10 p. m., 202 revolutions; 9.30 p. m., 202 revolutions; 9.50 p. m., 202 revolutions.

Log of producer-gas test No. 12, Kentucky No. 3 coal, November 25, 26, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Auxiliary motors.				Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.			Gas calorimeter.				B. T. U.		
					Watt meter.		Ammeter.	1.	2.	Volts.	Amperes.	Gas.		Temperatures (° C.).		Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.				
					1.	2.								Inlet.	Outlet.								
																				1.	2.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
8.50 p. m.		6,315,710	63.0		2.3	0.0		28.0	(a)		226	619				18.0	10.80	16.00	1,340	0.2	138.1	139.8	
9 p. m.	300	6,322,600	63.0		2.3	— .3	447,050	33.0	(a)		240	624				17.5	10.70	15.70	1,250	.2	124.8	125.0	
9.10 p. m.		6,329,450	62.5		2.3	+.5		34.0	a 1,715		239	619				17.5	10.80	16.10	1,340	.2	143.8	144.8	
9.20 p. m.		6,335,500	62.0		2.3	+.4		34.0	(a)	72,621	240	624		0.5	5.5								
9.30 p. m.		6,341,400	62.5	111,742	2.4	.5	449,050	28.0		74,540	239	624				18.0	10.80	15.90	1,420	.2	143.6	145.5	
9.40 p. m.	300	6,347,300	62.5		2.4	.5		31.0		76,553	239	634		.5	5.0		17.5	10.80	15.90	1,430	.2	144.4	145.3
9.50 p. m.		6,353,200	63.0		2.4	.4		28.0		78,576	240	624				17.5	10.90	16.10	1,500	.2	154.7	154.8	
10 p. m.		6,358,950	63.5		2.4	.4	450,850	26.0		80,597	238	624		.65	7.0	17.0	10.70	15.70	1,550	.2	153.9	154.2	
10.10 p. m.		6,365,500	63.0		2.3	.0		37.5		82,619	241	629				16.5	10.70	15.10	1,600	.2	139.9	140.8	
10.20 p. m.	300	6,371,900	63.0		2.3	.2		45.0		84,640	240	624				17.0	10.80	15.50	1,750	.2	163.1	153.3	
10.30 p. m.		6,378,180	62.5	112,106	2.3	.3	453,210	36.0		86,663	240	619				7.0	10.80	15.30	1,800	.2	160.7	160.8	
10.40 p. m.		6,384,800	62.0		2.3	— .2		36.0		88,678	237	624				16.5	10.80	14.90	1,750	.2	142.4	143.4	
10.50 p. m.																							
11 p. m.																							
11.10 p. m.																							
11.20 p. m.																							
11.30 p. m.	300																						
11.40 p. m.																							
11.50 p. m.																							
12 p. m.																							
12.10 a. m. ^b																							
12.15 a. m.	300																						
12.20 a. m.																							
12.30 a. m.																							

^a November 26.

Log of producer-gas test No. 12, Kentucky No. 3 coal, November 25, 26, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (°F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.	Load.		Temperature of gas leaving producer (°C.).	Manometers at pro- ducer.			Temperatures (°C.).			Cubic centimeters of water collected.	Cubic feet of gas.	B. T. U.		
					1.	2.	Watt meter.	Ammeter.		1.	2.		Volts.	Amperes.	Air entering (inches mer- cury).	Gas leaving wa- ter).	Gas.	Inlet.			Outlet.	Water.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
12.30 p. m.		6,613,890	70.0		2.3	0.0		24.0		61,230	235	609		0.60	7.0	26.0	11.20	18.30	1,050	0.2	148.0		154.0
12.40 p. m.	300																						
12.45 p. m.		6,620,450	70.0		2.3	.0		31.0		63,240	239	609											
12.50 p. m.																							
1 p. m.		6,627,000	70.0		2.3	.0	479,350	25.0		65,252	239	614				25.0	11.00	18.20	1,100	.2	157.1	162.8	
1.10 p. m.																							
1.20 p. m.		6,633,400	69.5		2.3	.0		32.0		67,264	240	624				23.5	10.80	18.20	1,000	.2	146.8	151.5	
1.30 p. m.	300																						
1.40 p. m.		6,639,810	69.0		2.3	.1		30.0		69,277	240	624				22.0	10.80	18.20	1,050	.2	154.3	158.4	
1.50 p. m.																							
2 p. m.		6,646,300	69.0	114,185	2.3	.1	481,090			71,280	237	614				22.0	10.70	16.80	1,150	.2	139.3	143.3	
2.10 p. m.																							

OPERATIONS OF THE COAL-TESTING PLANT.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
8.30 a. m. ^a	8.4	0.2	13.6	14.3	4.9	58.6	100.0	149.4
10.30 a. m.	8.4	.0	12.6	10.4	7.3	61.3	100.0	157.9
12.30 p. m.	10.40	.0	13.8	9.5	7.1	59.2	100.0	156.8
3 p. m.	11.0	.4	11.8	10.6	7.4	58.8	100.0	156.9
4.30 p. m.	11.0	.2	12.8	8.6	8.0	59.4	100.0	160.0
6.30 p. m.	10.0	.8	14.2	10.2	7.1	57.7	100.0	160.4
8.30 p. m.	11.6	.8	11.8	7.2	6.6	62.0	100.0	136.6
10.30 p. m.	11.0	.2	10.8	14.5	5.0	58.5	100.0	141.4
12.30 a. m. ^b	12.4	.4	12.6	11.3	4.8	58.5	100.0	134.4
2.30 a. m.	11.6	.4	13.4	11.9	6.0	56.7	100.0	152.1
4.30 a. m.	11.6	.2	13.0	9.0	6.0	60.2	100.0	142.7
6.30 a. m.	11.6	.4	12.4	13.9	4.8	56.9	100.0	142.8
8.30 a. m.	11.4	.0	11.8	10.4	7.4	59.0	100.0	156.2
10.30 a. m.	11.4	.2	10.8	8.1	9.3	60.2	100.0	164.9
12.30 p. m.	11.2	.2	11.4	12.4	6.1	58.7	100.0	147.9

^a November 25. ^b November 26.

Producer-gas test No. 12, ^a Kentucky No. 3 coal.

[Recorded by W. C. Weldmann and R. W. Cummings, November 25, 26, 1904.]

1. Duration of test, in hours 30

AVERAGE TEMPERATURE, ° F.

2. Gas leaving producer

3-6. See footnote on p. 1027.

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

7. Total steam used by producer	pounds..	7,740
8. Steam used by producer per hour	do.....	258
9. Equivalent in pounds of coal per hour		40.8
10. Equivalent in pounds of dry coal per hour		37.9
11. Equivalent in pounds of combustible per hour		34.2
12. Average horsepower required to drive auxiliary machinery		10.7
13. Total water used in scrubber and tar extractor.....	cubic feet..	4,390
14. Cubic feet of water per hour per horsepower of producer plant		.586
15. Cubic feet of water per 1,000 cubic feet of gas produced		7.73

^a Gas-producer hopper leaked.

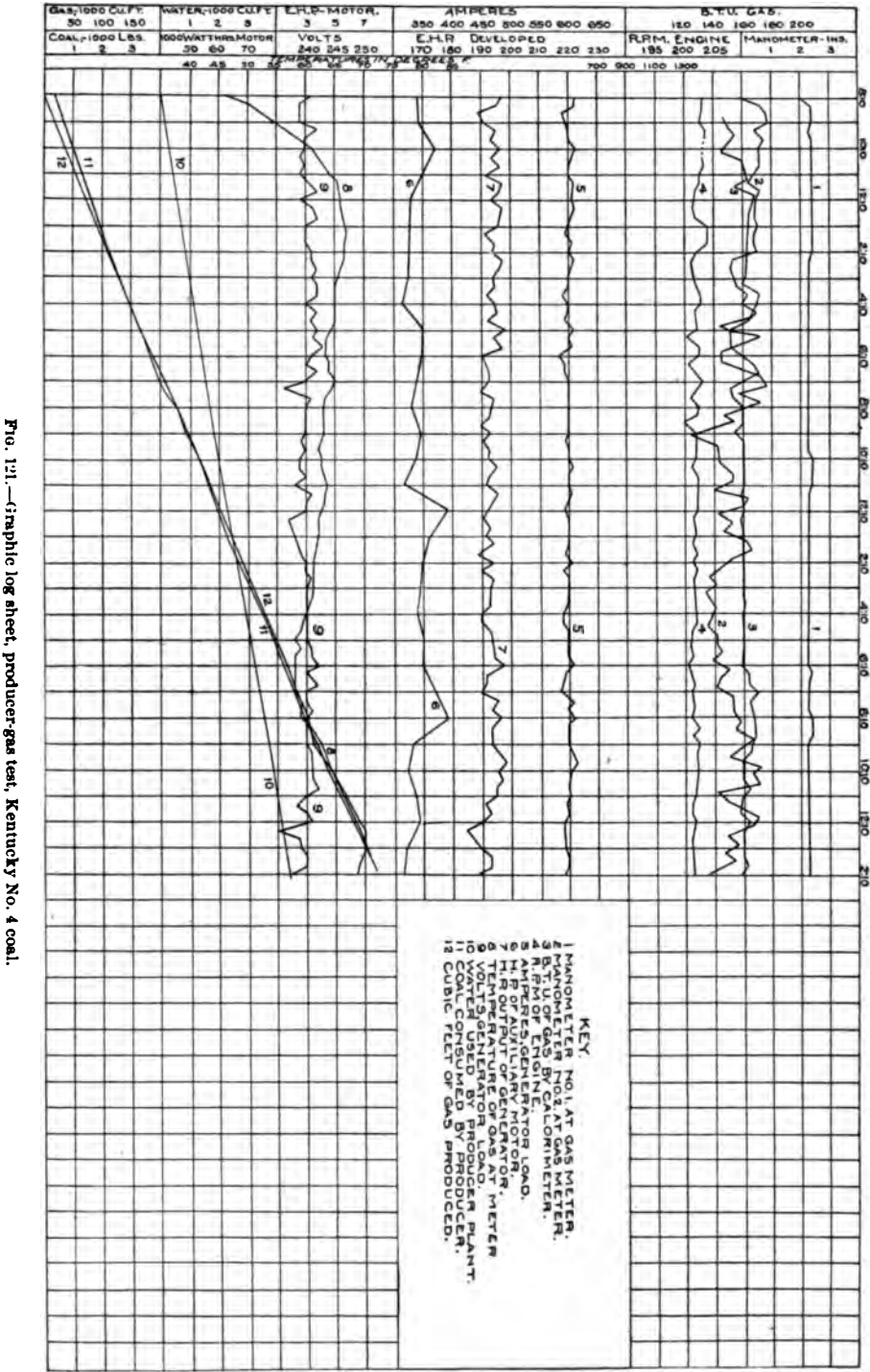


Fig. 121.—Graphical log sheet, producer-gas test, Kentucky No. 4 coal.

OPERATIONS OF THE COAL-TESTING PLANT.

COAL CONSUMED IN PRODUCER.

16. Total coal consumed	pounds..	11,100
17. Moisture in coal	per cent..	7.28
18. Total dry coal consumed	pounds..	10,300
19. Refuse from coal	per cent..	9.69
20. Total refuse from coal	pounds..	1,000
21. Total combustible consumed	do....	9,300

COAL PER HOUR.

22. Coal consumed in producer	pounds..	370
23. Dry coal consumed in producer	do....	343.3
24. Combustible consumed in producer	do....	310
25. Equivalent coal used by producer plant	do....	410.8
26. Equivalent dry coal used by producer plant	do....	381.2
27. Equivalent combustible used by producer plant	do....	344.2

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired		9.61
29. Dry coal		8.92
30. Combustible		8.06

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired		12,283
32. Per pound of dry coal		13,226
33. Per pound of combustible		14,650
34. From coal as fired, per hour		4,540,000
35. From dry coal, per hour		4,540,000
36. From combustible, per hour		4,540,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total		568,295
38. Per hour		18,943
39. Per pound coal consumed in producer		51.2
40. Per pound dry coal consumed in producer		55.1
41. Per pound combustible consumed in producer		61.1
42. Per pound equivalent coal used by producer plant		46.2
43. Per pound equivalent dry coal used by producer plant		49.7
44. Per pound equivalent combustible used by producer plant		55

PRODUCER-GAS TESTS.

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BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	155.9
46. Per pound dry coal burned in producer.....	8,610
47. Per hour per brake horsepower.....	12,540

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	189.8
49. Electrical horsepower developed at switch board.....	200.5
50. Brake horsepower available for outside purposes.....	223.5
51. Brake horsepower developed at engine.....	235.5

EFFICIENCIES.

52. Of conversion and cleaning gas.....	.650
53. Of producer plant.....	.583

COAL PER HORSEPOWER PER HOUR.

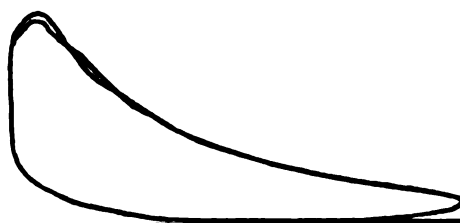
	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	1.95	1.81	1.63
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	1.85	1.71	1.55
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	1.66	1.54	1.39
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	1.57	1.46	1.32
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	2.16	2.01	1.81
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	2.05	1.91	1.72
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	1.84	1.71	1.54
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	1.75	1.62	1.46

^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	7.28	Carbon dioxide (CO ₂).....	10.87
Volatile matter.....	38.57	Oxygen (O ₂).....	.29
Fixed carbon.....	45.16	Carbon monoxide (CO).....	12.45
Ash.....	8.99	Hydrogen (H ₂).....	10.92
	100.00	Methane (CH ₄).....	6.52
		Nitrogen (N ₂).....	58.95
Sulphur.....	3.86		100.00

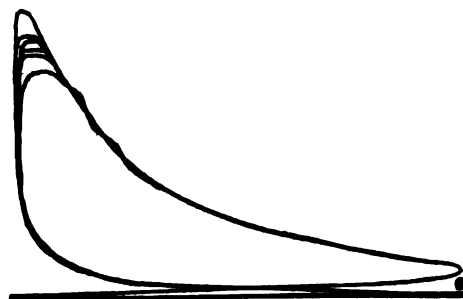
Kentucky No. 3 is a hard bituminous coal and burns in the producer with a hard top crust. It yielded a good gas of uniform quality and 100 gallons of clean black tar. It is well adapted for producer gas.



Right cylinder. M. E. P., 61; Max., 180; Rel., 22; I. H. P., 97.19



Center cylinder. M. E. P., 60; Max., 254; Rel., 30; I. H. P., 96.5.



Left cylinder. M. E. P., 60; Max., 230; Rel., 29; I. H. P., 96.5.

Indicator diagrams taken November 25, 1904, during gas-engine test No. 12, on Kentucky No. 3 coal. Revolutions per minute, 202.2.

GAS ENGINE.

The report of the engine operator is as follows:

"The gas was good during this test and everything was satisfactory with the exception of some trouble with the engine due to the fact that the ignition was set too early. The engine should be equipped with a device for changing the time of the spark while the engine is running. The gas from different coals requires different ignition settings. The gas from one coal often changes enough during the test to make a change in the setting necessary. These changes in the gas can be readily traced by the indicator cards from these tests. Until the engine is fitted with an ignition device that will permit a change in the time of the spark while the engine is running, there will be more or less trouble from this source."

The cards selected are representative of the entire test. They show late ignition and slow combustion.

The results of tests made on gas engine are shown in the following table:

Report of gas-engine test No. 12.

Recorded by R. W. Cummings and W. C. Weidmann, November 25, 26, 1904.

Producer test No. 12.

Coal: General number, Kentucky No. 3; special number, G. P. 12. Car initials and number, L. and N. 62714.

Duration of test, in hours.....	30
Revolutions per minute (mean).....	202
Explosions per minute (mean)	101
Cubic feet gas per hour, by meter.....	18,947
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	18,933
Maximum pressure:	
First cylinder.....	277.07
Second cylinder	250.31
Third cylinder.....	250.61
Pressure at release:	
First cylinder.....	28.77
Second cylinder	31.46
Third cylinder.....	27.15
Mean effective pressure:	
First cylinder.....	57.46
Second cylinder	59.31
Third cylinder.....	55.0
Indicated horsepower:	
First cylinder.....	91.51
Second cylinder	94.52
Third cylinder.....	88.39
Total indicated horsepower.....	274.4
Horsepower delivered (electrical horsepower)	200.5
Mechanical efficiency (engine and generator combined)	72.9 per cent.
Cubic feet standard gas per hour per indicated horsepower.....	69
Cubic feet standard gas per hour per electrical horsepower.....	94.6

MISSOURI No. 2.

GENERAL RESULTS.

The general results of tests of Missouri No. 2 coal are tabulated below:

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Log of producer-gas test No. 7, Missouri No. 2 coal, November 3, 1904.

[Coal from mine No. 8 of the Northwestern Coal and Mining Company, near Bevier, Mo.]

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Gas calorimeter.						B. T. U.			
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Temperatures (° C.).		Cubic centimeters of water collected.	Cubic feet of gas.	As read.			Standardized.	
																	Inlet.	Outlet.							
																									17	18	19	20	21	22
8.20 a. m. a.	300	3,716,060	57.0	61,040	2.3	-0.6		29.5	23,102	63,102	243	624	460	0.60	6.5										
8.30 a. m.	300																								
8.40 a. m.	300	3,723,810	58.5		2.2	+	.3	30.0	25,093	65,093	241	619	520												
9 a. m.	300	3,731,025	60.0		2.2	0		30.0	27,088	67,088	239	619	490	.55	6.5										
9.10 a. m.																									
9.20 a. m.		3,737,800	62.0		2.2	+	.6	28.0	29,094	69,094	239	614	485			17.6	13.5	19.15	1,820	0.3	134.9	136.4			
9.30 a. m.	300																								
9.40 a. m.		3,744,210	63.5		2.3	.6		28.0	31,100	71,100	239	619	440	.55	7.0										
9.50 a. m.																									
10 a. m.		3,750,610	65.0		2.3	.5		29.0	33,107	73,107	239	624	445												
10.10 a. m.																									
10.15 a. m.	300																								
10.20 a. m.		3,757,490	65.0		2.2	0	144,600	28.0	35,092	75,092	240	624	450	.60	7.5										
10.30 a. m.																									
10.40 a. m.		3,764,550	65.0		2.1	0		30.0	37,087	77,087	239	624	440			25.0	14.0	20.52	1,020	.2	131.7	137.6			
10.50 a. m.																									
10.55 a. m.	300																								
11 a. m.		3,771,640	65.0		2.2	3		30.0	39,082	79,082	242	619	440	.60	7.0										
11.10 a. m.																									
11.20 a. m.		3,778,650	66.0		2.2	1	146,530	30.5	41,083	81,083	237	609	455			19.5	13.6	20.29	1,000	.2	130.7	133.7			
11.30 a. m.																									
11.37 a. m.																									
11.40 a. m.	300	3,786,320	68.0		2.0	5		34.5	43,057	83,057	234	629	540	.60	8.0										
12 m.		3,793,480	71.0		2.2	+	.3	28.0	45,031	85,031	240	614	505			20.0	13.6	18.37	1,370	.2	129.4	132.6			
12.20 p. m.		3,800,900	74.0		1.8	3	148,610	33.0	47,015	87,015	236	609	480			20.0	13.5	18.00	1,280	.2	114.3	117.2			
12.40 p. m.																									
12.50 p. m.																									
1.00 p. m.																									
1.10 p. m.																									
1.20 p. m.																									
1.30 p. m.																									
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10.20 p. m.																									
10.30 p. m.																									
10.40 p. m.																									
10.50 p. m.																</									

a November 3. Barometer 29.28 inches.

Log of producer-gas test No. 7, Missouri No. 2 coal, November 8, 1904—Continued.

[illegible]

Log of producer-gas test No. 7, Missouri No. 2 coal, November 3, 1904—Continued.

Time.	(Coal consumed by producer (pounds).	(Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Temperatures (° C.).				Cubic feet of gas.		B. T. U.	
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Gas entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	As read.	Standardized.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
5.10 p. m.		3,914,740	90.0		1.5	-1.3											17.0	13.4	16.90	1,580	0.3	73.0	73.9
5.20 p. m.		3,933,000	74.5	62,562	1.6	-3		35.0	77,252	17,252	238	417	640										
7 p. m.								35.0	86,500	26,500	240	619	380										
7.15 p. m.	300																						
7.20 p. m.		3,940,450	74.5		1.8	.0		40.0	88,532	28,532	241	614	430	1.10	9.0	17.0	13.3	18.24	1,200	.2	117.5	119.1	
7.40 p. m.		3,947,550	73.5		2.0	+4		38.0	90,583	30,583	239	614	440			17.0	13.6	19.52	1,150	.2	134.8	136.3	
7.45 p. m.																							
8 p. m.	300	3,954,000	72.0		2.1	.8		42.0	92,604	32,604	240	619	420			17.0	13.4	19.40	1,250	.2	142.8	144.8	
8.05 p. m.																							
8.20 p. m.		3,960,200	71.5		2.2	.9		35.0	94,614	34,614	239	619	430	.60	6.0	17.0	13.5	19.45	1,240	.2	144.0	146.0	
8.25 p. m.																							
8.40 p. m.		3,966,600	70.0		2.2	.9	168,460	39.5	96,621	36,621	238	619	400			17.0	13.6	19.90	1,000	.2	146.8	148.7	
8.45 p. m.	300																						
8.50 p. m.																							
9 p. m.		3,972,790	69.5	63,102	2.2	.8		35.0	98,633	38,633	238	614	440			18.0	13.6	19.71	1,150	.2	138.3	141.7	
9.10 p. m.																							
9.20 p. m.		3,979,200	69.0		2.1	.5		35.5	627	40,627	240	619	470			17.0	13.6	18.63	1,400	.2	138.7	141.5	
9.35 p. m.																							
9.40 p. m.		3,985,900	68.5		2.1	.2	170,790	42.0	2,620	42,620	241	629	440	.65	6.75	16.0	13.6	19.30	1,170	.2	132.1	133.5	
9.45 p. m.	300															19.0	13.8	18.50	1,460	.2	142.2	145.2	
10 p. m.		3,992,900	68.0		2.0	.0		40.0	4,622	44,622	240	619	530										
10.15 p. m.																							
10.20 p. m.		4,000,000	68.5		2.1	.0		44.0	6,622	46,622	240	599	460										
10.30 p. m.	300																						
10.40 p. m.		4,007,200	68.5		1.5	-1	173,280	41.0	8,402	48,402	240	619	470	1.10	8.0	18.0	13.8	17.78	1,500	.2	98.4	100.0	

^a Could not carry full load. At 5.20 p. m. the load was taken off to allow the producer bed to be brought to a better condition. Coal was charged into the producer at 5.20, 6.15, 6.30, and 6.40. The test was resumed at 7 p. m. with the producer bed in proper condition and the engine carrying full load.

Log of producer-gas test No. 7, Missouri No. 2 cond, November 3, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motor.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Gas calorimeter.				B. T. U.				
		3	4	5	6	7	8	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	14	15	16	Gas.	Temperatures (° C.).		Cubic centimeters of water collected.		As read.	Standardized.	
																		Inlet.	Outlet.	Gas.	Water.			
11 p. m.	4,014,100	68.0	68.0	63,651	2.1	+0.7		35.0	10,412	50,412	240	619	510				18.0	13.8	19.52	1,220	0.2	138.0	140.3	
11:05 p. m.	4,020,580	68.0			2.1	.7		41.0	12,422	52,422	240	629	500	0.65	6.75									
11:20 p. m.																								
11:30 p. m.	800	4,026,800	67.5		2.2	.8	175,690	35.0	14,432	54,432	240	614	410				18.0	13.4	19.44	1,900	.3	150.8	153.2	
11:45 p. m.					2.2	.9		33.0	16,444	56,444	240	609	450				17.5	13.5	18.50	1,450	.2	144.0	146.0	
12 p. m.		4,032,590	67.5		2.2			36.0	18,455	58,455	241	629	480				19.0	13.6	18.80	1,350	.2	136.3	139.1	
12:05 a. m.					2.3	.7											19.0	13.4	17.88	2,150	.3	128.2	130.8	
12:20 a. m. ^a		4,039,230	67.0																					
12:25 a. m. ^b																								
12:40 a. m.																								
12:45 a. m.																								

^a November 4.

^b 12:25 a. m. Two of the exhaust valves stuck. The engine stopped and the test was discontinued.

OPERATIONS OF THE COAL-TESTING PLANT.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
8.40 a. m	9.6	0.0	12.6	2.1	1.8	73.9	100.0	70.5
10.40 a. m	12.2	.4	11.4	7.3	2.4	66.3	100.0	90.8
12.55 p. m	12.0	.6	11.4	7.9	5.4	62.7	100.0	124.8
3.20 p. m	12.8	.8	10.8	7.6	5.7	62.3	100.0	124.8
7.15 p. m	13.0	.0	9.4	9.8	5.5	62.3	100.0	125.4
9.15 p. m	11.2	.6	11.2	6.9	5.5	64.6	100.0	121.7
11.15 p. m	12.0	.0	11.0	6.2	8.0	62.8	100.0	145.2

Producer-gas test No. 7A,^a Missouri No. 2 coal.

[Recorded by M. H. Mount and R. E. Peshak, November 3, 1904.]

1. Duration of test, in hours 6.33

AVERAGE TEMPERATURE, ° F.

2. Gas leaving producer 883

3-6. (See footnote on p. 1027.)

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

9. Equivalent in pounds of coal per hour 57.4
10. Equivalent in pounds of dry coal per hour 50.8
11. Equivalent in pounds of combustible per hour 42.3
12. Average horsepower required to drive auxiliary machinery 11.3
13. Total water used in scrubber and tar extractor cubic feet.. 757.9
14. Cubic feet of water per hour per horsepower of producer plant 479
15. Cubic feet of water per 1,000 cubic feet of gas produced 5.67

COAL CONSUMED IN PRODUCER.

16. Total coal consumed pounds.. 3,300
17. Moisture in coal per cent.. 11.60
18. Total dry coal consumed pounds.. 2,920
19. Refuse from dry coal per cent.. 16.79
20. Total refuse from coal pounds.. 490
21. Total combustible consumed do.. 2,430

COAL PER HOUR.

22. Coal consumed in producer pounds.. 522
23. Dry coal consumed in producer do.. 462
24. Combustible consumed in producer do.. 384
25. Equivalent coal used by producer plant do.. 579.4
26. Equivalent dry coal used by producer plant do.. 512.8
27. Equivalent combustible used by producer plant do.. 426.3

^a Gas-producer hopper leaked. Test No. 7 was divided into two parts, as explained on p. 1165.

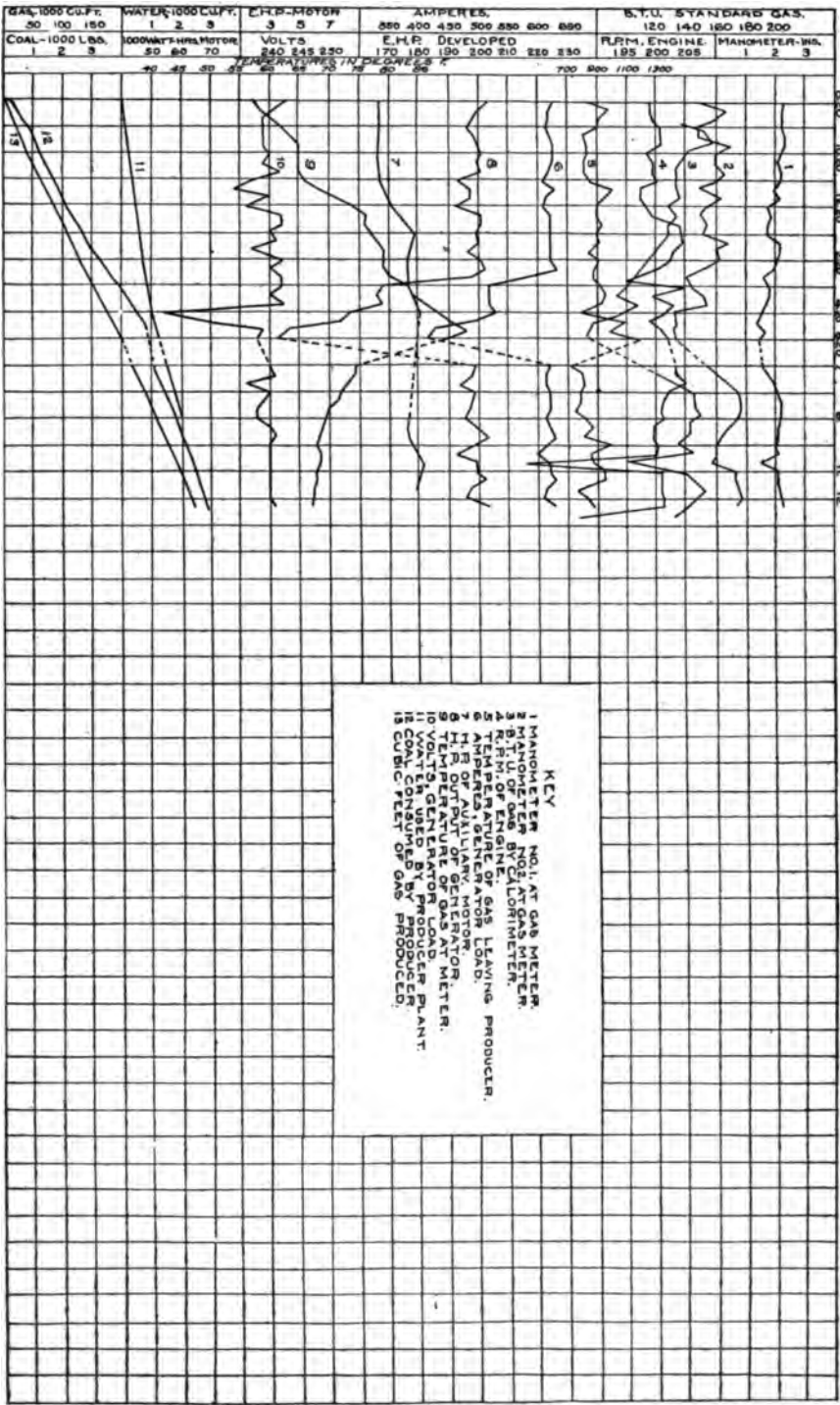


Fig. 122.—Graphic log sheet, producer-gas test, Missouri No. 2 coal.

OPERATIONS OF THE COAL-TESTING PLANT.

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired	13.6
29. Dry coal	12
30. Combustible	10

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	10,505
32. Per pound of dry coal.....	11,882
33. Per pound of combustible.....	14,280
34. From coal as fired, per hour.....	5,490,000
35. From dry coal, per hour.....	5,490,000
36. From combustible, per hour.....	5,490,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total	133,579
38. Per hour.....	21,100
39. Per pound coal consumed in producer.....	40.5
40. Per pound dry coal consumed in producer.....	45.8
41. Per pound combustible consumed in producer.....	55
42. Per pound equivalent coal used by producer plant.....	36.4
43. Per pound equivalent dry coal used by producer plant.....	41.2
44. Per pound equivalent combustible used by producer plant.....	49.5

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	135.6
46. Per pound dry coal burned in producer.....	6,200
47. Per hour per brake horsepower.....	12,200

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	187.7
49. Electrical horsepower developed at switch board.....	199
50. Brake horsepower available for outside purposes.....	221
51. Brake horsepower developed at engine.....	234

EFFICIENCIES.

52. Of conversion and cleaning gas.....	.52
53. Of producer plant.....	.47

PRODUCER-GAS TESTS.

1163

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes	2.78	2.46	2.05
55. Pounds consumed in producer per electrical horsepower developed at switch board	2.62	2.32	1.93
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes	2.36	2.09	1.74
57. Pounds consumed in producer per brake horsepower ^a developed at engine	2.23	1.98	1.64
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	3.09	2.73	2.27
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board	2.91	2.58	2.14
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes	2.62	2.32	1.93
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine	2.48	2.19	1.83

^aBased on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture	11.60	Carbon dioxide (CO ₂)	11.27
Volatile matter	35.28	Oxygen (O ₂)	.33
Fixed carbon	38.28	Carbon monoxide (CO)	11.80
Ash	14.84	Hydrogen (H ₂)	5.77
	100.00	Methane (CH ₄)	3.20
		Nitrogen (N ₂)	67.63
Sulphur	4.56		100.00

Producer-gas test No. 7B,^a Missouri No. 2 coal.

[Recorded by M. H. Mount and R. E. Peshak, November 3, 1904.]

1. Duration of test, in hours	4.33
-------------------------------------	------

AVERAGE TEMPERATURE, ° F.

2. Gas leaving producer	856
3-6. (See footnote on page 1027.)	

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

9. Equivalent in pounds of coal per hour	38
10. Equivalent in pounds of dry coal per hour	33.6
11. Equivalent in pounds of combustible per hour	28
12. Average horsepower required to drive auxiliary machinery	12.9
13. Total water used in scrubber and tar extractor cubic feet..	1,189.5
14. Cubic feet of water per hour per horsepower of producer plant	1.10
15. Cubic feet of water per 1,000 cubic feet of gas produced	14.3

^aGas-producer hopper leaked.

OPERATIONS OF THE COAL-TESTING PLANT.

COAL CONSUMED IN PRODUCER.

16. Total coal consumed	pounds..	1,500
17. Moisture in coal	per cent..	11.6
18. Total dry coal consumed	pounds..	1,328
19. Refuse from coal	per cent..	16.79
20. Total refuse from coal	pounds..	223
21. Total combustible consumed	do....	1,103

COAL PER HOUR.

22. Coal consumed in producer	pounds..	348.5
23. Dry coal consumed in producer	do....	306
24. Combustible consumed in producer	do....	255
25. Equivalent coal used by producer plant	do....	384.5
26. Equivalent dry coal used by producer plant	do....	339.6
27. Equivalent combustible used by producer plant	do....	283

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired		9
29. Dry coal		7.96
30. Combustible		6.62

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired		10,505
32. Per pound of dry coal		11,882
33. Per pound of combustible		14,280
34. From coal as fired, per hour		3,640,000
35. From dry coal, per hour		3,640,000
36. From combustible, per hour		3,640,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total		83,545
38. Per hour		19,300
39. Per pound coal consumed in producer		55.7
40. Per pound dry coal consumed in producer		63
41. Per pound combustible consumed in producer		75.7
42. Per pound equivalent coal used by producer plant		50.2
43. Per pound equivalent dry coal used by producer plant		56.8
44. Per pound equivalent combustible used by producer plant		68.2

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot		140
46. Per pound dry coal burned in producer		8,820
47. Per hour per brake horsepower		11,560

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes		185.7
49. Electrical horsepower developed at switch board		198.6
50. Brake horsepower available for outside purposes		218.5
51. Brake horsepower developed at engine		233.5

PRODUCER-GAS TESTS.

1165

EFFICIENCIES.

52. Of conversion and cleaning gas	0.742
53. Of producer plant.....	.664

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes	1.87	1.65	1.37
55. Pounds consumed in producer per electrical horsepower developed at switch board	1.74	1.54	1.28
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes	1.59	1.40	1.17
57. Pounds consumed in producer per brake horsepower ^a developed at engine	1.48	1.31	1.09
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	2.07	1.83	1.52
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	1.94	1.71	1.43
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes	1.76	1.55	1.30
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine	1.65	1.45	1.21

^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture	11.60	Carbon dioxide (CO ₂)	12.07
Volatile matter	35.28	Oxygen (O ₂)	.20
Fixed carbon	38.28	Carbon monoxide (CO)	10.53
Ash.....	14.84	Hydrogen (H ₂)	7.63
	100.00	Methane (CH ₄)	6.33
		Nitrogen (N ₂)	63.24
Sulphur	4.56		100.00

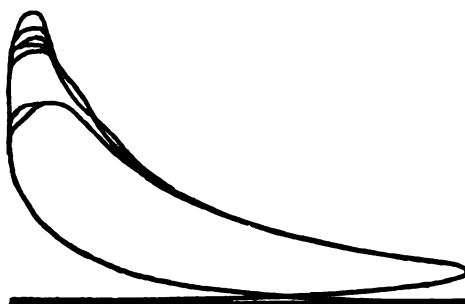
GAS ENGINE.

In making up the report of this test it was necessary to divide the test into two distinct parts. The fuel bed was not in very good condition during the early part of the run, and after 2.40 p. m. considerable difficulty was experienced from this source. Test 7A includes that part of the run from 8.20 a. m. to 2.40 p. m., or 6.33 hours.

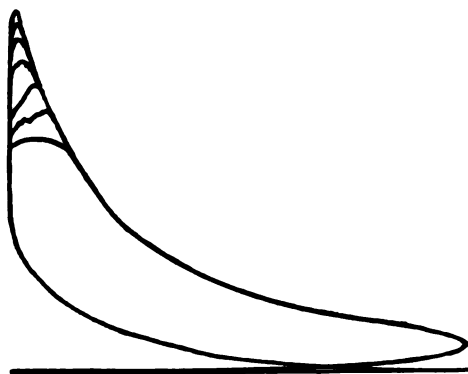
At 5.20 p. m. the load was taken off the engine in order to give an opportunity for building up the producer bed. Records were resumed at 8 p. m. under good conditions and everything indicated a successful run. At 12.25 a. m. November 4 two of the engine exhaust valves stuck and the engine stopped. The report No. 7B is based on the run from 8 p. m. to 12.20 a. m.

In reporting on this coal the gas-producer operator says:

"In using Missouri No. 2 coal some difficulty was experienced in keeping the bed in good condition, owing to its tendency to break open in spots. The high percentage of sulphur in the coal did not add to its value as a producer fuel, but the



Right cylinder. M. E. P., 60; Max., 225; Rel., 32; I. H. P., 94.6.



Center cylinder. M. E. P., 62; Max., 266; Rel., 34; I. H. P., 97.7.



Left cylinder. M. E. P., 50; Max., 187; Rel., 32; I. H. P., 79.

Indicator diagrams taken November 3, 1904, during gas-engine test No. 7B, on Missouri No. 2 coal. Scale of spring, 80; revolutions per minute, 200.2.

writer's opinion is that it can be used in producers by increasing the facilities for purifying."

For item 9, as in test No. 5, 11 per cent of the coal fired was taken.

In the indicator cards shown the combustion is seen to be rather slow, and the ignition is late in the right and left cylinders.

PRODUCER-GAS TESTS.

1167

Report of gas-engine test No. 7A.

Recorded by R. W. Cummings and W. C. Weidmann, November 3, 1904.

Producer test No. 7 A.

Coal: General number, Missouri No. 2; special number, S. C. 7A. Car initials and number, C., B. and Q. 86827.

Duration of test, in hours.....	6½
Revolutions per minute (mean).....	200
Explosions per minute (mean).....	100
Cubic feet gas per hour, by meter.....	21,600
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	21,100
Maximum pressure:	
First cylinder.....	223.3
Second cylinder.....	280
Third cylinder.....	200.7
Pressure at release:	
First cylinder.....	33
Second cylinder.....	34
Third cylinder.....	30.7
Mean effective pressure:	
First cylinder.....	63.3
Second cylinder.....	62
Third cylinder.....	54
Indicated horsepower:	
First cylinder.....	100.6
Second cylinder.....	98.4
Third cylinder.....	86.1
Total indicated horsepower.....	285.1
Horsepower delivered (electrical horsepower).....	199
Mechanical efficiency (engine and generator combined).....per cent..	69.8
Cubic feet standard gas per hour per indicated horsepower.....	74
Cubic feet standard gas per hour per electrical horsepower.....	106

Report of gas-engine test No. 7B.

Recorded by R. W. Cummings and W. C. Weidmann, November 3, 1904.

Producer test No. 7B.

Coal: General number, Missouri No. 2; special number, G. P. 7B. Car initials and number, C., B. and Q. 86827.

Duration of test, in hours.....	4½
Revolutions per minute (mean).....	198.9
Explosions per minute (mean).....	99.45
Cubic feet gas per hour, by meter.....	19,690
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	19,290

Maximum pressure:	
First cylinder.....	240.7
Second cylinder.....	278.7
Third cylinder.....	189.7
Pressure at release:	
First cylinder.....	30.7
Second cylinder.....	31.3
Third cylinder.....	31
Mean effective pressure:	
First cylinder.....	59.3
Second cylinder.....	58.7
Third cylinder.....	51
Indicated horsepower:	
First cylinder.....	94
Second cylinder.....	92.9
Third cylinder.....	80.8
Total indicated horsepower.....	267.7
Horsepower delivered (electrical horsepower)	198.6
Mechanical efficiency (engine and generator combined).....per cent..	74.2
Cubic feet standard gas per hour per indicated horsepower.....	72.1
Cubic feet standard gas per hour per electrical horsepower.....	97.1

MONTANA No. 1.**GENERAL RESULTS.**

The general results of tests of Montana No. 1 coal are tabulated as follows:

PRODUCER-GAS TESTS.

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Log of producer-gas test No. 5, Montana No. 1 coal, October 24, 25, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of Gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).	Auxiliary motors.		Speed counters on gas engine.	Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.	Gas calorimeter.				B. T. U.						
						Ammeter.			Volts.	Amperes.			Temperatures (° C.).		Cubic centimeters of water collected.	Cubic feet of gas.							
						1.	2.						Gas.	Inlet.				Water.	As read.	Standardized.			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
5.15 p. m.		2,798,050	69.0		2.5	1.7		23.0	7,109	47,109	242	619		0.4	5.0	23.8	15.00	24.41	1,260	0.3	156.7	162.8	
5.20 p. m.																							
5.30 p. m.	300																						
5.35 p. m.		2,805,220	69.0		2.4	1.6		22.5	9,125	49,125	243	614		.4	5.0	21.0	15.00	24.60	1,200	.3	151.6	166.5	
5.40 p. m.																							
5.55 p. m.		2,808,300	69.0		2.4	1.6	48,850	23.5	11,145	51,145	242	619		.4	5.0	21.0	15.00	24.57	1,360	.3	173.7	179.2	
6 p. m.	300																						
6.15 p. m. ^a		2,813,390	69.0	49,522	2.0	1.6		24.5	13,165	53,165	243	619				19.5	15.00	23.95	1,350	.3	159.5	163.8	
6.20 p. m.																							
6.30 p. m.	300																						
6.35 p. m.		2,818,780	69.0		2.3	.9		27.0	15,176	55,176	249	609		.3	7.0	18.5	15.00	21.29	1,120	.2	139.7	142.9	
6.40 p. m.																							
6.55 p. m.		2,825,190	69.0		2.3	.8		25.0	17,186	57,186	241	614	500			20.5	15.00	21.38	1,020	.2	129.0	132.9	
7.10 p. m.																							
7.15 p. m.	300	2,831,220	69.0		2.2	.9		28.0	19,196	59,196	242	619	420	.6	5.0	20.0	14.90	22.00	1,060	.2	139.3	143.3	
7.30 p. m.																							
7.35 p. m.		2,837,000	69.0		2.2	1.2		26.0	21,211	61,211	243	614	420			19.0	14.90	21.09	1,650	.3	149.0	152.9	
7.45 p. m.	300																						
7.50 p. m.																							
7.55 p. m.		2,842,750	69.0		2.4	1.1		23.0	23,229	63,229	241	609	390	.4	5.0	19.0	14.90	22.19	1,700	.3	163.5	167.7	
8.10 p. m.																							
8.15 p. m.		2,848,250	70.0	49,992	2.4	1.3		23.0	25,248	65,248	242	596	340			20.0	15.00	21.36	1,180	.2	148.8	153.1	
8.30 p. m.																							
8.35 p. m.	300	2,853,900	70.5		2.4	1.3		28.0	27,265	67,265	240	619	400	.7	7.0	18.0	15.00	21.00	1,240	.2	147.6	150.7	

"6.15 p. m. October 21 to 7.55 a. m. October 25, barometer 29.76 inches.

Log of producer-gas test No. 5, Montana No. 1 coal, October 24, 25, 1904—Continued.

Time.	Coal consumed by producer (pounds).			Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).			Auxiliary motors.			Speed counters on gas engine.			Load.			Temperature of gas leaving producer (° C.).	Manometers at producer.			Gas calorimeter.				
	1	2	3			4	5	1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	14	15		16	Temperatures (° C.).			Cubic centimeters of water collected.	Cubic feet of gas.	B. T. U.	
																				Gas.	Inlet.	Outlet.			As read.	Standardized.
3.55 p. m.			2,850,600	70.0																						
9 p. m.	300							53,800	27.0	29,278	66,278	241	629		350	0.3	4.0									
9.10 p. m.																										
9.15 p. m.			2,865,170	71.0																						
9.30 p. m.									27.0	31,293	71,293	241	619	300												
9.35 p. m.																										
9.40 p. m.	300		2,870,650	70.5					26.0	33,315	73,315	241	619	300		6	6.0									
9.50 p. m.																										
9.55 p. m.			2,875,990	70.0				55,410	25.0	35,333	75,333	241	619	300												
10.10 p. m.																										
10.15 p. m.			2,881,150	70.0	49,931				27.0	37,353	77,353	241	619	320		8	7.5									
10.30 p. m.	300																									
10.35 p. m.			2,886,210	69.0					26.0	39,373	79,373	240	619	300		65	6.5									
10.50 p. m.																										
10.55 p. m.			2,891,510	68.0					26.0	41,393	81,393	241	619	360												
11.10 p. m.																										
11.30 p. m.	300		2,896,850	67.0					27.0	43,408	83,408	238	609	370		6.5										
11.35 p. m.																										
11.50 p. m.			2,902,510	66.5					27.0	45,410	85,410	240	619	400												
11.55 p. m.																										
12.10 p. m.			2,907,950	66.0				58,760	27.0	47,422	87,422	239	619	340		6.5										
12 p. m.	300																									
12.10 a. m. ^a																										
12.15 a. m.			2,914,610	66.0					28.0	49,439	89,439	242	619	340		6	6.5									
12.30 a. m.	300																									

Log of producer-gas test No. 5, Montana No. 1 coal, October 23, 25, 1904—Continued.

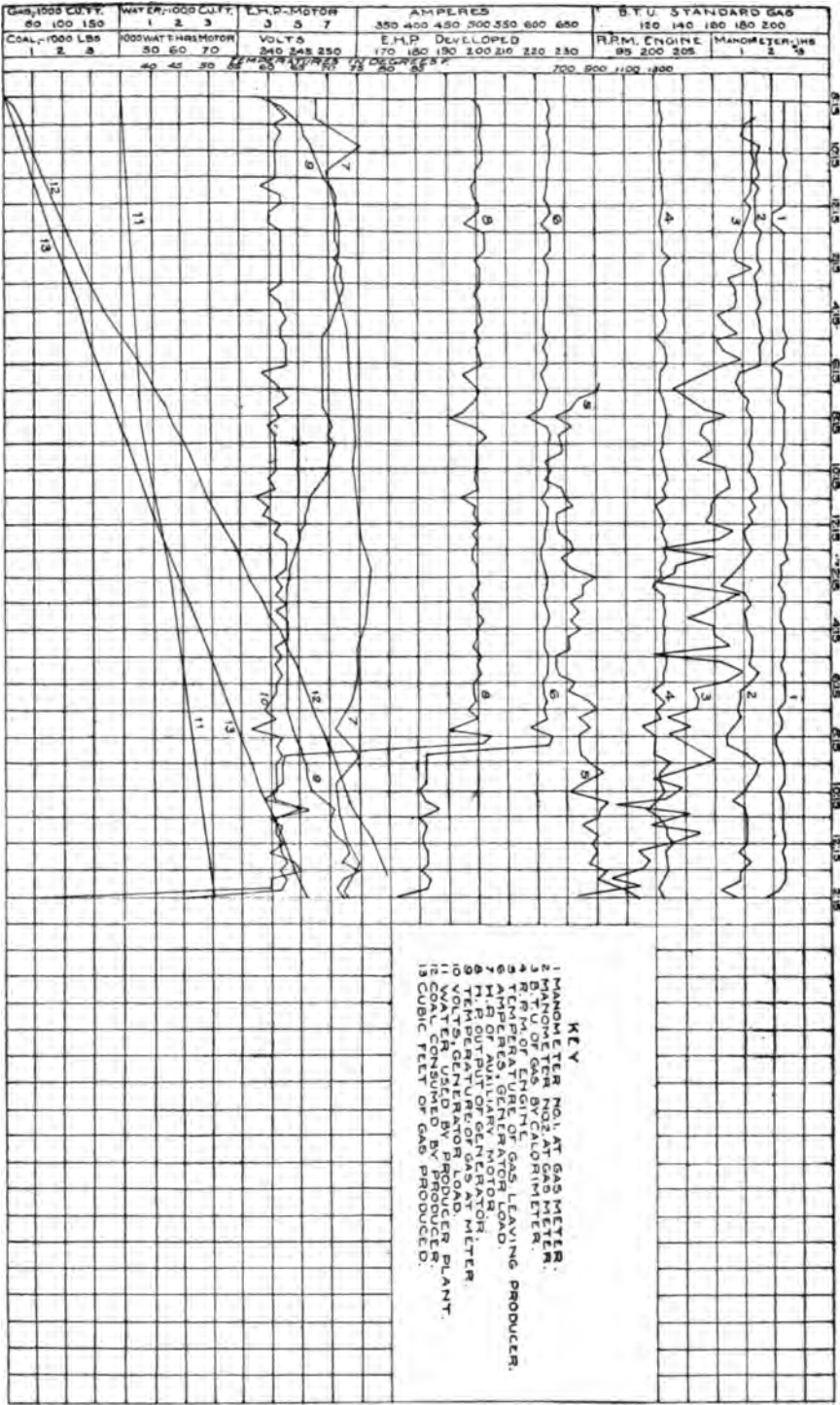
Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.	Temperatures (° C.).				Gas calorimeter.				B. T. U.											
		3	4		5	6	7	8	9	10	11	12	13	14			15	16	17	18	19	20	21	22		23										
																											1	2	1	2	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	As read.	Standardized.
12.35 a. m.					2.5	1.0			27.0	51,452	91,452	241	614	350	0.45	5.0																				
12.50 a. m.																	18.0	15.30	24.46	1,750	0.4	150.9	163.2													
12.55 a. m.					2.5	1.1	60,500	30.0	53,472	93,472	243	614	300	.45	4.0																					
1 a. m.	300																																			
1.10 a. m.																	19.0	15.3	22.95	1,850	.4	121.4	124.6													
1.15 a. m.					2.4	1.3			29.0	55,498	95,498	243	609	400	.5	4.7																				
1.30 a. m.																	19.5	15.4	23.00	1,900	.4	154.8	158.8													
1.35 a. m.					2.5	1.1			26.0	57,507	97,507	243	609	360	.5	4.5																				
1.45 a. m.	300																																			
1.50 a. m.																	19.0	15.3	22.60	1,800	.4	130.6	134.0													
1.55 a. m.					2.3	.9	62,330	27.0	59,517	99,517	243	614	300	.5	4.7																					
2.10 a. m.																	17.0	15.2	21.95	1,450	.3	130.5	132.8													
2.15 a. m.					2,946,940	63.5	50,592		29.0	61,529	1,529	241	619	480	.5	4.5																				
2.30 a. m.	300																16.0	15.25	20.46	2,350	.4	121.4	123.2													
2.35 a. m.					2,956,820	63.0			29.0	63,535	3,535	242	619	440	.4	4.2																				
2.50 a. m.																	16.0	15.35	23.72	2,100	.4	175.0	177.5													
2.55 a. m.					2,963,120	63.0			28.0	65,551	5,551	241	614	440	.5	4.8																				
3 a. m.	300																																			
3.15 a. m.					2,968,980	63.0			28.0	67,565	7,565	243	614	300	.5	5.4																				
3.30 a. m.																	17.0	15.30	22.30	1,650	.3	152.8	155.4													
3.35 a. m.					2,974,820	63.0			27.0	69,581	9,581	241	619	420	.5	5.2																				
3.45 a. m.	300																																			
3.50 a. m.																	18.0	15.40	21.77	1,650	.3	139.7	142.7													
3.55 a. m.					2,980,800	63.0			27.0	71,595	11,595	243	619	300	.6	6.3																				
4.10 a. m.																	20.0	15.40	22.50	2,200	.4	155.1	159.6													
4.15 a. m.	300	2,986,540	63.0	50,870	2.4	1.1			26.0	73,612	13,612	243	614	420	.6	6.0																				

PRODUCER-GAS TESTS.

Log of producer-gas test No. 5, Montana No. 1 coal, October 24, 25, 1904—Continued.

Time.	(Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Temperatures (° C.).				Gas calorimeter.		B. T. U.
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Outlet.	(Cubic centimeters of water collected.	(Cubic feet of gas.	As read.	Standardized.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
12.35 p. m.		3,133,560	73.0		2.3	0.8		25.0	23,847	63,847	240	415	485	0.5	5.5								
12.40 p. m.	300																						
12.50 p. m.		3,139,350	72.0		2.4	1.2	79,830	20.0	25,865	65,865	244	415	460	5	5.2		24.0	15.20	23.06	1,800	0.5	112.7	116.1
12.55 p. m.																							
1.10 p. m.																	24.0	15.40	23.14	1,400	.4	107.5	110.7
1.15 p. m.		3,144,930	72.0		2.4	.9		19.0	27,885	67,885	245	405	520	6	6.6								
1.30 p. m.	300																24.0	15.30	20.76	1,600	.4	87.3	89.9
1.35 p. m.		3,151,260	72.0		2.4	.9		27.5	29,897	69,897	240	420	490										
1.50 p. m.																							
1.55 p. m.		3,157,350	71.0		2.2	.2	81,320	25.0	31,908	71,908	240	415	500	3	3.5		23.0	15.20	23.23	1,350	.4	107.1	110.0
2.10 p. m.																							
2.15 p. m.		3,165,230	72.0	52,110	1.8	.8		25.0	33,914	73,914	201	358	640				23.0	15.20	18.64	1,450	.3	65.1	66.8

FIG. 123.—Graphic log sheet, producer-gas test, Montana No. 1 coal.



GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
8.15 a. m.	3.2	0.8	23.9	6.9	4.3	60.9	100.0	153.2
10.15 a. m.	5.8	.2	21.6	10.6	7.1	54.7	100.0	187.9
12.15 p. m.	6.2	.4	22.8	10.1	5.5	55.0	100.0	173.3
2.15 p. m.	7.4	.5	21.7	6.0	6.9	57.5	100.0	170.1
4.15 p. m.	7.8	.8	20.8	4.5	3.9	62.2	100.0	129.8
6.15 p. m.	9.6	.6	19.4	10.8	3.7	55.9	100.0	144.7
8.15 p. m.	10.6	.2	17.2	10.2	3.9	57.9	100.0	137.1
10 p. m.	10.0	.2	16.8	9.5	5.5	58.0	100.0	150.3
12 p. m.	11.8	.0	14.7	5.88	2.94	64.68	100.0	103.1
2 a. m.	11.8	.6	15.0	.38	4.07	68.15	100.0	97.4
4 a. m.	11.0	.0	15.0	10.66	5.33	58.01	100.0	146.2
6 a. m.	10.4	.4	18.2	8.0	8.0	55.0	100.0	176.6
8 a. m.	11.8	.0	15.6	10.5	1.8	60.3	100.0	110.2
10 a. m.	12.4	.0	11.4	5.49	3.66	67.05	100.0	97.9
12 m.	12.0	.0	11.6	.0	4.89	71.51	100.0	92.7
2 p. m.	13.4	.2	9.6	.0	3.7	73.1	100.0	72.9
2.15 p. m.	14.2	.0	6.8	.0	1.3	77.7	100.0	37.6

Producer-gas test No. 5A, Montana No. 1 coal.^a

[Recorded by M. H. Mount and R. E. Peshak, October 24, 25, 1904.]

1. Duration of test, in hours.....	22.33
AVERAGE TEMPERATURE, ° F.	
2. Gas leaving producer.....	737.6
3-6. (See footnote on p. 1027.)	
OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
9. Equivalent in pounds of coal per hour.....	50.3
10. Equivalent in pounds of dry coal per hour.....	44.6
11. Equivalent in pounds of combustible per hour.....	39.2
12. Average horsepower required to drive auxiliary machinery.....	8.5
13. Total water used in scrubber and tar extractor..... cubic feet..	2,264
14. Cubic feet of water per hour per horsepower of producer plant.....	.406
15. Cubic feet of water per 1,000 cubic feet of gas produced.....	6.13
COAL CONSUMED IN PRODUCER.	
16. Total coal consumed..... pounds..	10,200
17. Moisture in coal..... per cent..	11.40
18. Total dry coal consumed..... pounds..	9,037
19. Refuse from dry coal..... per cent..	12.12
20. Total refuse from coal..... pounds..	1,095
21. Total combustible consumed..... do....	7,942

^a Gas-producer hopper leaked. Test No. 5 was divided into two parts, as explained on p. 1180.

PRODUCER-GAS TESTS.

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Log of producer-gas test No. 5, Montana No. 1 coal, October 24, 25, 1904—Continued.

Time.	Coal consumed by producer (pounds).		Gas meter (cubic feet).		Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Gas calorimeter.																	
											Watt meter.		Ammeter.								1. 2.		Volts.		Amperes.		Temperatures (° C.).				Cubic centimeters of water collected.				Cubic feet of gas.		B. T. U.	
																											Gas.	Inlet.	Outlet.	17	18	19	20	21				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23																
5.15 p. m.		2,798,050	69.0		2.5	1.7		23.0	7,109	47,109	242	619		0.4	5.0	23.8	15.00	24.41	1,260	0.3	156.7	162.8																
5.20 p. m.	300																																					
5.30 p. m.		2,803,220	69.0		2.4	1.6		22.5	9,125	49,125	243	614		.4	5.0	21.0	15.00	24.60	1,200	.3	151.6	166.5																
5.35 p. m.																																						
5.40 p. m.		2,808,300	69.0		2.4	1.6		48,850	11,145	51,145	242	619		.4	5.0	21.0	15.00	24.57	1,300	.3	173.7	179.2																
5.55 p. m.	300																																					
6 p. m.		2,813,380	69.0	49,522	2.0	1.6		24.5	13,165	53,165	243	619				19.5	15.00	23.95	1,350	.3	159.5	163.8																
6.15 p. m.																																						
6.20 p. m.	300																																					
6.30 p. m.		2,818,740	69.0		2.3	.9		27.0	15,176	55,176	249	400		.3	7.0	18.5	15.00	21.29	1,120	.2	138.7	142.9																
6.35 p. m.																																						
6.40 p. m.		2,825,190	69.0		2.3	.8		25.0	17,186	57,186	241	614	500			20.5	15.00	21.38	1,020	.2	129.0	132.9																
7.10 p. m.																																						
7.15 p. m.	300	2,831,220	69.0		2.2	.9		28.0	19,196	59,196	242	619	420	.6	5.0	20.0	14.90	22.00	1,060	.2	130.3	143.3																
7.30 p. m.																																						
7.35 p. m.		2,837,000	69.0		2.2	1.2		26.0	21,211	61,211	243	614	420																									
7.45 p. m.	300																																					
7.50 p. m.		2,842,750	69.0		2.4	1.1		23.0	23,229	63,229	241	609	380	.4	5.0	19.0	14.90	21.69	1,650	.3	149.0	152.9																
7.55 p. m.																																						
8.10 p. m.		2,846,250	70.0	49,692	2.4	1.3		23.0	25,248	65,248	242	586	340			19.0	14.90	22.19	1,700	.3	163.5	167.7																
8.15 p. m.																																						
8.30 p. m.		2,853,900	70.5		2.4	1.3		28.0	27,265	67,265	240	619	400	.7	7.0	20.0	15.00	21.36	1,180	.2	148.8	153.1																
8.35 p. m.	300																																					
8.50 p. m.																																						
																					</																	

"6.15 p. m. October 24 to 7.55 a. m. October 25, barometer 29.76 inches.

Log of producer-gas test No. 5, Montana No. 1 coal, October 24, 25, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Manometers at producer.		Temperatures (° C.).				(gas calorimeter.		B. T. U.	
		1.	2.	1.	2.	1.	2.	1.	2.	1.	2.	1.	2.	1.	2.	Volts.	Ampers.	Air entering (inches mercury).	Gas leaving (inches water).	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.
1		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23						
8.55 p. m.		2.4	1.3	53,800	27.0	29,278	69,278	241	629	350	0.3	4.0													
9 p. m.	300																								
9.10 p. m.		2.4	1.2																						
9.15 p. m.		2,865,170	71.0		27.0	31,293	71,293	241	619	300															
9.30 p. m.																									
9.35 p. m.		2,870,050	70.5		26.0	33,315	73,315	241	619	300	.6	6.0													
9.40 p. m.	300																								
9.50 p. m.																									
9.55 p. m.		2,875,990	70.0		25.0	35,353	75,353	241	619	300															
10.10 p. m.																									
10.15 p. m.		2,881,150	70.0		27.0	37,353	77,353	241	619	320	.8	7.5													
10.30 p. m.	300																								
10.35 p. m.		2,886,210	69.0		26.0	39,373	79,373	240	619	300	.65	6.5													
10.50 p. m.																									
10.55 p. m.		2,891,510	68.0		26.0	41,393	81,393	241	619	300															
11.10 p. m.																									
11.15 p. m.	300	2,896,850	67.0		27.0	43,408	83,408	238	609	370	.6	6.5													
11.30 p. m.																									
11.35 p. m.		2,902,510	66.5		27.0	45,410	85,410	240	619	400															
11.50 p. m.																									
11.55 p. m.		2,907,950	66.0		27.0	47,422	87,422	239	619	340	.6	6.5													
12 p. m.	300																								
12.10 a. m. ^a																									
12.15 a. m.		2,914,610	66.0		28.0	49,439	89,439	242	619	340	.6	6.5													
12.30 a. m.	300																								

^aOctober 25.

Log of producer-gas test No. 5, Montana No. 1 coal, October 24, 25, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of Gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of Gas leaving producer (° C.).		Manometers at producer.		Temperatures (° C.).				Gas calorimeter.		B. T. U.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
		3	4	5	1	2	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
																									Gas meter (cubic feet).		Temperature of Gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).	Auxiliary motors.	Speed counters on gas engine.	Load.	Temperature of Gas leaving producer (° C.).	Manometers at producer.	Temperatures (° C.).	Gas calorimeter.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												

Log of producer-gas test No. 5, Montana No. 1 coal, October 24, 25, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of Gas (° F.).	Auxiliary motors.				Speed counters on gas engine.				Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.	Temperatures (° C.).				Gas calorimeter.		B. T. U.
				Watt meter.		Ammeter.	1. 2.		Volts.	Amperes.	Gas.	Inlet.	Outlet.			Cubic centimeters of water collected.	(Cubic feet of gas.					
				1.	2.		1.	2.														
1			4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
4.30 a. m.																						
4.35 a. m.		2,992,240	63.0		2.4	1.3		26.0	75,628	15,628	243	614	380	0.4	4.3	20.0	15.40	22.06	1,750	0.3	155.2	159.6
4.50 a. m.																						
4.55 a. m.		2,997,740	63.0		2.4	1.3	67,550	26.0	77,645	17,645	241	614	390	.4	4.3	20.0	15.40	22.00	1,900	.3	165.9	170.6
5 a. m.	300																					
5.10 a. m.																						
5.15 a. m.		3,003,070	63.0		2.4	1.3		26.0	79,664	19,664	242	619	340	.4	4.6	20.0	15.40	21.80	1,800	.4	114.3	117.6
5.30 a. m.	300																					
5.35 a. m.		3,008,510	63.0		2.3	1.2		26.0	81,683	21,683	241	619	340	.4	4.3	18.0	15.30	21.56	1,400	.2	175.0	178.2
5.50 a. m.																						
5.55 a. m.		3,013,670	63.0		2.4	1.5	69,220	25.0	83,698	23,698	242	619	350	.4	4.6	17.0	15.20	21.28	2,000	.3	161.5	169.5
6.10 a. m.																						
6.15 a. m.		3,018,900	63.0	51,123	2.4	1.3		26.0	85,714	25,714	241	614	400	.6	5.3	17.0	15.20	20.14	1,450	.2	140.9	143.5
6.30 a. m.	300																					
6.35 a. m.		3,024,840	63.0		2.4	.9		26.0	87,710	27,710	241	614	380		6.5	16.5	15.00	20.12	1,450	.2	146.8	149.2
6.50 a. m.																						
6.55 a. m.		3,030,650	63.0		2.4	.9	70,800	22.0	89,725	29,725	240	619	455	.6	5.2	16.5	15.00	20.12	1,500	.2	146.0	148.4
7.10 a. m.																						
7.15 a. m.		3,036,790	63.0		2.2	.8		21.0	91,725	31,725	239	614	490	.5	4.	16.5	15.30	19.00	1,700	.2	125.0	127.0
7.30 a. m.																						
7.35 a. m.		3,043,220	63.5		2.3	.9		24.0	93,734	33,734	241	619	420	.4	4.4	16.5	15.30	19.00	1,700	.2	125.0	127.0
7.45 a. m.	300																					
7.50 a. m.																						
7.55 a. m.		3,048,320	64.0		2.3	.7	72,180	20.0	95,714	35,714	237	599	460	.6	4.5	16.5	14.75	19.30	1,550	.2	141.3	143.6
8.10 a. m.	300																					
8.15 a. m.		3,055,350	64.5	51,357	2.1	.4		26.0	97,714	37,714	242	629	420	.6	5.0	17.0	15.15	18.60	2,800	.3	127.8	128.6

Log of producer-gas test No. 5, Montana No. 1 coal, (October 24, 25, 1904—Continued).

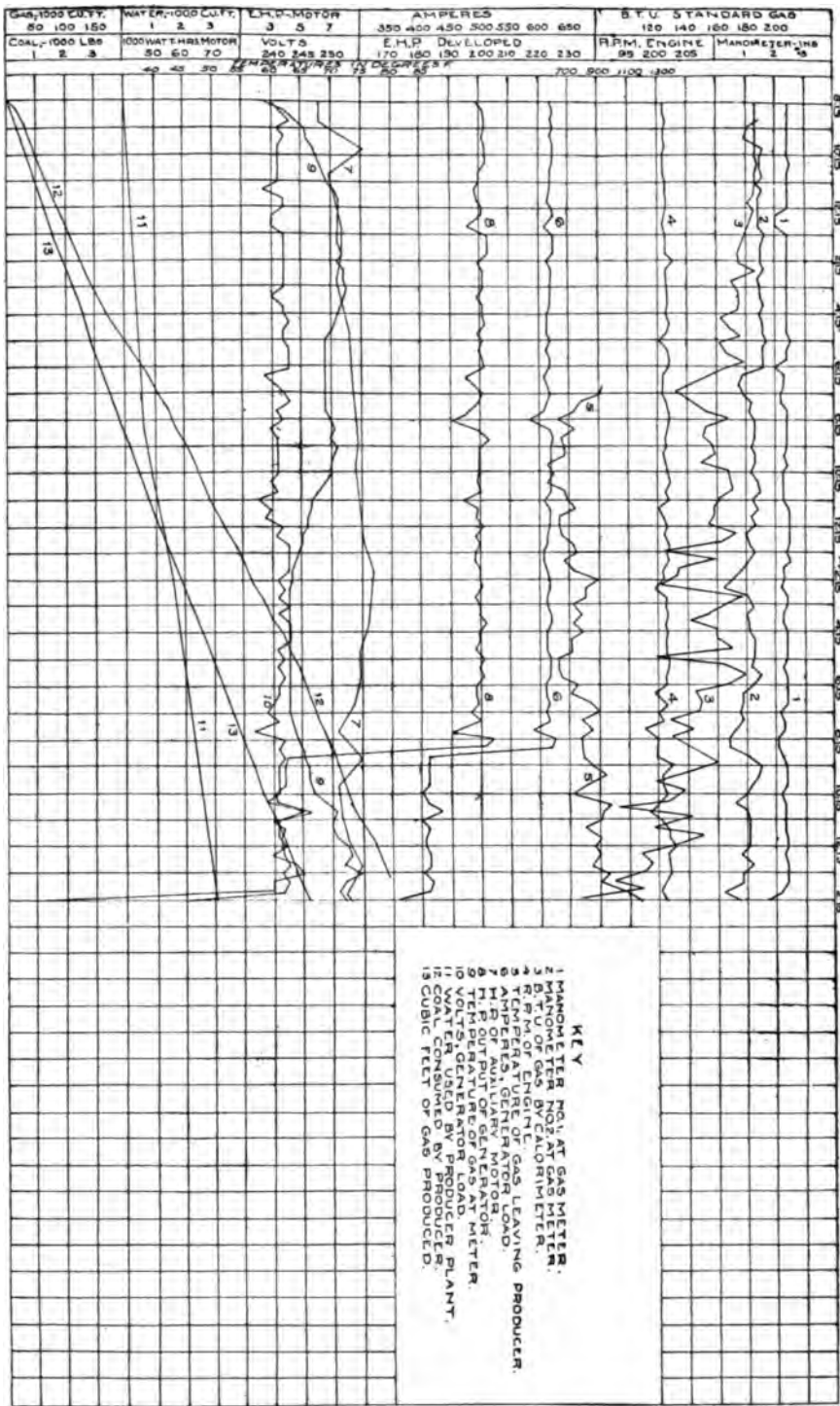
Time.	Coal consumed by producer (pounds).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors. on gas engine.			Load.	Temperature of gas leaving producer (° C.).	Manometers at producer.	Temperatures (° C.).				Gas calorimeter.			B. T. U.					
				1.	2.	Watt meter.	Ammeter.	Speed counters on gas engine.				Volts.	Amperes.	Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Water.	Outlet.	(Cubic centimeters of water collected).	(Cubic feet of gas.	As read.	Standardized.	
1	16	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
8.35 a. m.						2.1	0.4		26.0	99,713	39,713	241	624	420	0.5	4.5								
8.50 a. m.	300	3,062,360	65.0																					
8.55 a. m.		3,069,240	65.5			2.3	1.1	73,870	27.0	1,712	41,712	242	a 415	430				16.5	14.90	18.64	2,150	0.2	157.9	156.5
9.10 a. m.						2.4	1.5		18.0	3,735	43,735	241	415	460	.1	2.0		17.0	14.95	18.24	2,200	.2	144.0	144.9
9.15 a. m.		3,074,280	66.0															20.0	14.95	18.10	1,850	.2	117.5	119.4
9.30 a. m.		3,079,250	66.0			2.4	1.4		18.0	5,744	45,744	241	415	510	.1	3.5		20.0	14.95	18.10	1,850	.2	117.5	119.4
9.35 a. m.																		20.0	15.00	18.68	1,850	.2	135.7	137.9
9.50 a. m.	300	3,085,350	66.5			2.4	1.2	75,260	20.0	7,752	47,752	241	415	435	.1	3.5		20.0	15.00	18.68	1,850	.2	135.7	137.9
9.55 a. m.																		21.0	15.05	18.78	1,700	.2	125.0	127.4
10.10 a. m.																		21.0	15.05	18.78	1,700	.2	125.0	127.4
10.15 a. m.		3,091,060	67.0			2.2	1.0		18.0	9,765	49,765	241	405	390				24.0	15.20	17.75	1,850	.2	91.7	94.4
10.30 a. m.		3,097,280	68.0			2.3	.6		20.0	11,769	51,769	239	410	530				24.0	15.20	17.75	1,850	.2	91.7	94.4
10.35 a. m.																		24.0	15.20	17.75	1,850	.2	91.7	94.4
10.50 a. m.	300	3,105,000	70.5			2.3	1.0	76,680	16.0	13,757	53,757	245	435	500	.15	3.5		22.0	15.15	19.72	2,300	.3	140.0	143.2
11.10 a. m.																		22.0	15.15	19.72	2,300	.3	140.0	143.2
11.15 a. m.		3,110,500	70.0			2.3	1.1		19.0	15,761	55,761	241	400	480	.2	4.0		22.0	15.15	19.72	2,300	.3	140.0	143.2
11.30 a. m.	300																	22.0	15.20	18.60	1,700	.2	114.7	117.3
11.35 a. m.		3,116,720	70.0			2.3	1.1		25.0	17,780	57,780	241	415	440				22.0	15.20	18.60	1,700	.2	114.7	117.3
11.50 a. m.																		22.0	15.10	19.11	1,850	.2	146.8	150.1
11.55 a. m.		3,122,110	71.0			2.4	1.1	78,170	25.0	19,799	59,999	241	410	460	.2	3.5		22.0	15.10	19.11	1,850	.2	146.8	150.1
12 m.	300																							
12.10 p. m.																		25.5	15.40	22.38	2,300	.5	127.8	132.3
12.15 p. m.																		25.5	15.40	22.38	2,300	.5	127.8	132.3
12.30 p. m.		3,127,610	72.5	51,845	2.4	1.1			25.0	21,830	61,830	242	410	470				24.5	15.40	22.15	1,150	.3	103.6	106.9
12.30 p. m.																		24.5	15.40	22.15	1,150	.3	103.6	106.9

^a Quality of the gas fell off. Load had to be reduced.

Log of producer-gas test No. 5, Montana No. 1 coal, October 24, 25, 1904—Continued.

[illegible]

FIG. 123.—Graphic log sheet, producer-gas test, Montana No. 1 coal.



OPERATIONS OF THE COAL-TESTING PLANT.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
8.15 a. m.	3.2	0.8	23.9	6.9	4.3	60.9	100.0	153.2
10.15 a. m.	5.8	.2	21.6	10.6	7.1	54.7	100.0	187.9
12.15 p. m.	6.2	.4	22.8	10.1	5.5	55.0	100.0	173.3
2.15 p. m.	7.4	.5	21.7	6.0	6.9	57.5	100.0	170.1
4.15 p. m.	7.8	.8	20.8	4.5	3.9	62.2	100.0	129.8
6.15 p. m.	9.6	.6	19.4	10.8	3.7	55.9	100.0	144.7
8.15 p. m.	10.6	.2	17.2	10.2	3.9	57.9	100.0	137.1
10 p. m.	10.0	.2	16.8	9.5	5.5	58.0	100.0	150.3
12 p. m.	11.8	.0	14.7	5.88	2.94	64.68	100.0	103.1
2 a. m.	11.8	.6	15.0	.38	4.07	68.15	100.0	97.4
4 a. m.	11.0	.0	15.0	10.66	5.33	58.01	100.0	146.2
6 a. m.	10.4	.4	18.2	8.0	8.0	55.0	100.0	176.6
8 a. m.	11.8	.0	15.6	10.5	1.8	60.3	100.0	110.2
10 a. m.	12.4	.0	11.4	5.49	3.66	67.05	100.0	97.9
12 m.	12.0	.0	11.6	.0	4.89	71.51	100.0	92.7
2 p. m.	13.4	.2	9.6	.0	3.7	73.1	100.0	72.9
2.15 p. m.	14.2	.0	6.8	.0	1.3	77.7	100.0	37.6

Producer-gas test No. 5A, Montana No. 1 coal.^a

[Recorded by M. H. Mount and R. E. Peshak, October 24, 25, 1904.]

1. Duration of test, in hours.....	22.33
AVERAGE TEMPERATURE, ° F.	
2. Gas leaving producer.....	737.6
3-6. (See footnote on p. 1027.)	
OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
9. Equivalent in pounds of coal per hour.....	50.3
10. Equivalent in pounds of dry coal per hour.....	44.6
11. Equivalent in pounds of combustible per hour.....	39.2
12. Average horsepower required to drive auxiliary machinery.....	8.5
13. Total water used in scrubber and tar extractor..... cubic feet..	2,264
14. Cubic feet of water per hour per horsepower of producer plant.....	.406
15. Cubic feet of water per 1,000 cubic feet of gas produced.....	6.13
COAL CONSUMED IN PRODUCER.	
16. Total coal consumed..... pounds..	10,200
17. Moisture in coal..... per cent..	11.40
18. Total dry coal consumed..... pounds..	9,037
19. Refuse from dry coal..... per cent..	12.12
20. Total refuse from coal..... pounds..	1,095
21. Total combustible consumed..... do....	7,942

^a Gas-producer hopper leaked. Test No. 5 was divided into two parts, as explained on p. 1180.

PRODUCER-GAS TESTS.

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COAL PER HOUR.

22. Coal consumed in producer.....	pounds..	456. 5
23. Dry coal consumed in producer.....	do.....	404. 5
24. Combustible consumed in producer.....	do.....	355. 8
25. Equivalent coal used by producer plant.....	do.....	506. 8
26. Equivalent dry coal used by producer plant.....	do.....	449. 1
27. Equivalent combustible used by producer plant.....	do.....	395

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired	pounds..	11. 85
29. Dry coal	do.....	10. 50
30. Combustible	do.....	9. 25

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	10, 575
32. Per pound of dry coal.....	11, 934
33. Per pound of combustible.....	13, 580
34. From coal as fired, per hour.....	4, 825, 000
35. From dry coal, per hour.....	4, 825, 000
36. From combustible, per hour.....	4, 825, 000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	369, 500
38. Per hour.....	16, 540
39. Per pound coal consumed in producer.....	36. 23
40. Per pound dry coal consumed in producer.....	40. 89
41. Per pound combustible consumed in producer.....	46. 50
42. Per pound equivalent coal used by producer plant.....	32. 64
43. Per pound equivalent dry coal used by producer plant.....	36. 80
44. Per pound equivalent combustible used by producer plant.....	41. 90

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	160. 8
46. Per pound dry coal burned in producer.....	6, 580
47. Per hour per brake horsepower.....	11, 340

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	191
49. Electrical horsepower developed at switch board.....	199. 5
50. Brake horsepower available for outside purposes.....	224. 8
51. Brake horsepower developed at engine.....	234. 7

EFFICIENCIES.

52. Of conversion and cleaning gas.....	551
53. Of producer plant.....	495

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes	2. 39	2. 12	1. 86
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	2. 29	2. 03	1. 78
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	2. 03	1. 80	1. 58
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	1. 95	1. 72	1. 52
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	2. 65	2. 35	2. 07
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	2. 54	2. 25	1. 98
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	2. 26	2. 00	1. 76
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	2. 16	1. 91	1. 68

^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	11. 40	Carbon dioxide (CO ₂).....	9. 04
Volatile matter.....	34. 55	Oxygen (O ₂)	. 36
Fixed carbon.....	43. 31	Carbon monoxide (CO).....	18. 67
Ash.....	10. 74	Hydrogen (H ₂)	8. 00
	100. 00	Methane (CH ₄)	4. 84
Sulphur.....	1. 72	Nitrogen (N ₂)	59. 09
			100. 00

From 8.15 a. m. October 24 to 8.35 a. m. October 25 full load was carried. Owing to the fact that the producer was overcharged prior to beginning the official test at 8.15 a. m. October 24, the first two hours of the test have been disregarded in making up the report. The portion of the test designated as No. 5A begins with the records taken at 10.15 a. m. October 24 and ends with the 8.35 a. m. readings on October 25, making a test of 22.33 hours.

Owing to the clinkery condition of the fuel bed, it was difficult to keep the quality of the gas up to standard after 8.35 a. m. October 25, and consequently the load was reduced to about two-thirds of full load. Test No. 5B includes that portion of the test on this coal after the reduction of load. As there was a tendency of the producer operator to "hold" the last one or two charges of coal fed to the producer, the last hour of the test was not counted in making up the report of test No. 5B. The report includes 4.67 hours from 8.55 a. m. to 1.15 p. m. October 25. Although this second part of the test is very short and subject to possible inaccuracies on this account, yet the two parts of the run on this coal,

OPERATIONS OF THE COAL-TESTING PLANT.

COAL CONSUMED IN PRODUCER.

16. Total coal consumed.....	pounds..	1,800
17. Moisture in coal.....	per cent..	11.40
18. Total dry coal consumed.....	pounds..	1,595
19. Refuse from dry coal.....	per cent..	12.12
20. Total refuse from coal.....	pounds..	193
21. Total combustible consumed.....	do....	1,402

COAL PER HOUR.

22. Coal consumed in producer.....	pounds..	386
23. Dry coal consumed in producer.....	do....	342
24. Combustible consumed in producer.....	do....	300
25. Equivalent coal used by producer plant.....	do....	425.3
26. Equivalent dry coal used by producer plant.....	do....	376.8
27. Equivalent combustible used by producer plant.....	do....	330.6

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired.....	pounds..	10
29. Dry coal.....	do....	8.9
30. Combustible.....	do....	7.8

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	10,575
32. Per pound of dry coal.....	11,934
33. Per pound of combustible.....	13,580
34. From coal as fired, per hour.....	4,080,000
35. From dry coal, per hour.....	4,080,000
36. From combustible, per hour.....	4,080,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	81,500
38. Per hour.....	17,464
39. Per pound coal consumed in producer.....	15.2
40. Per pound dry coal consumed in producer.....	51
41. Per pound combustible consumed in producer.....	58.2
42. Per pound equivalent coal used by producer plant.....	41.1
43. Per pound equivalent dry coal used by producer plant.....	46.3
44. Per pound equivalent combustible used by producer plant.....	52.8

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	127.7
46. Per pound dry coal burned in producer.....	6,530
47. Per hour per brake horsepower.....	14,150

PRODUCER-GAS TESTS.

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AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	125. 8
49. Electrical horsepower developed at switchboard.....	133. 8
50. Brake horsepower available for outside purposes.....	148
51. Brake horsepower developed at engine.....	157. 4

EFFICIENCIES.

52. Of conversion and cleaning gas.....	. 546
53. Of producer plant.....	. 538

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	3. 07	2. 72	2. 38
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	2. 88	2. 56	2. 24
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	2. 61	2. 31	2. 03
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	2. 45	2. 17	1. 91
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	3. 38	3. 00	2. 63
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	3. 18	2. 81	2. 47
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	2. 88	2. 55	2. 23
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	2. 70	2. 39	2. 10

^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	11. 40	Carbon dioxide (CO ₂).....	13. 00
Volatile matter.....	34. 55	Oxygen (O ₂).....	. 05
Fixed carbon.....	43. 31	Carbon monoxide (CO).....	9. 85
Ash.....	10. 74	Hydrogen (H ₂).....	1. 37
	100. 00	Methane (CH ₄).....	3. 39
Sulphur.....	1. 72	Nitrogen (N ₂).....	72. 34
			100. 00

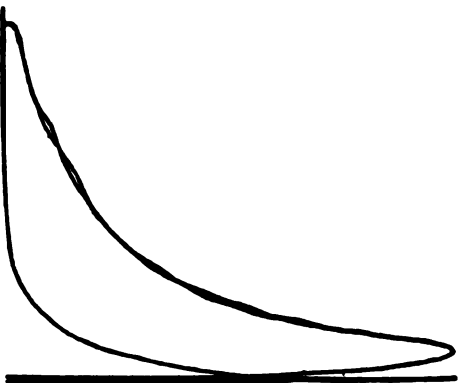
GAS ENGINE.

The results of gas-engine tests are as follows:

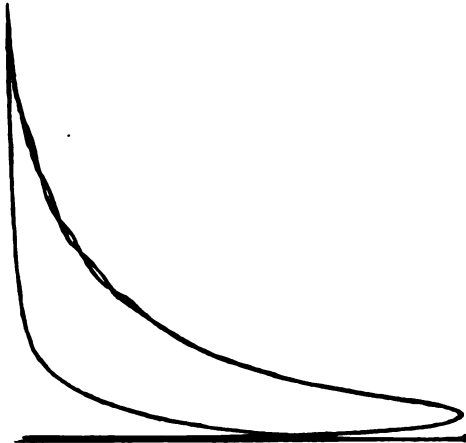
Report of gas-engine test No. 5A.

Recorded by R. W. Cummings and W. C. Weidmann, October 24, 25, 1904.
Coal: General number, Montana No. 1; special number, G. P. 5A. Car initials and number, C. B. and Q. 33808.

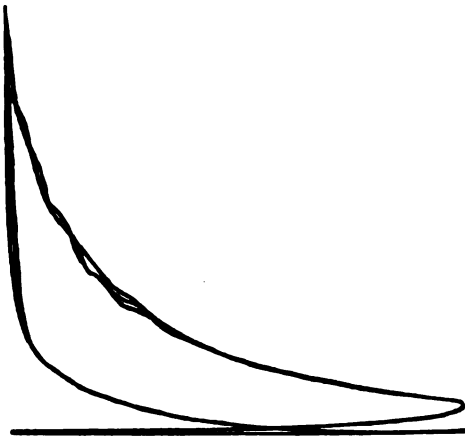
Duration of test, in hours	22½
Revolutions per minute (mean).....	201.3



Right cylinder. M. E. P., 67.5; Max., 300; Rel., 30; I. H. P., 107.



Center cylinder. M. E. P., 60; Max., 304; Rel., 30; I. H. P., 95.1

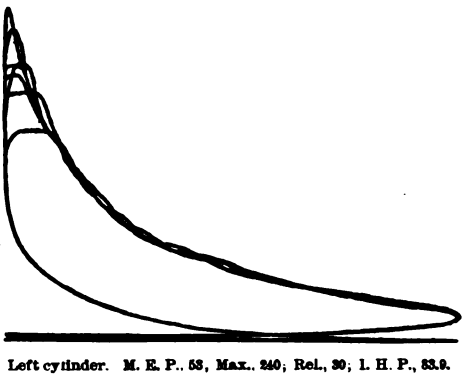
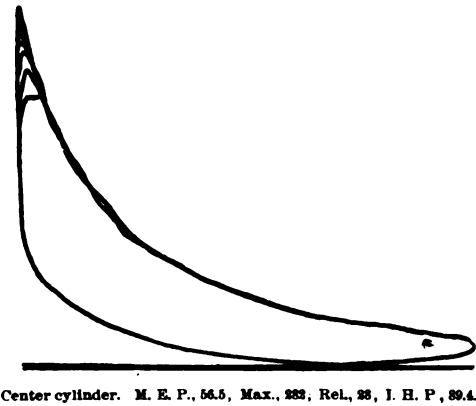
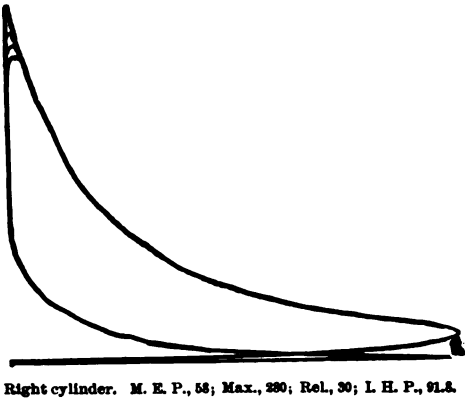


Left cylinder. M. E. P., 60; Max., 322; Rel., 32; I. H. P., 95.1

Indicator diagrams taken October 24, 1904, during gas-engine test No. 5A, on Montana No. 1 coal. Scale of spring, 80: revolutions per minute, 201.3.

Explosions per minute (mean).....	100.6
Cubic feet gas per hour, by meter.....	16,800
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure)	16,540

Maximum pressure:	
First cylinder.....	262.8
Second cylinder.....	280.2
Third cylinder.....	253.8
Pressure at release:	
First cylinder.....	29.7
Second cylinder.....	29.3
Third cylinder.....	40



Indicator diagrams taken October 24, 1904, during gas-engine test No. 5A, on Montana No 1 coal. Scale of spring, 80, revolutions per minute, 201

Mean effective pressure:	
First cylinder.....	60.1
Second cylinder.....	58.3
Third cylinder.....	<u>56</u>

Indicated horsepower:	
First cylinder.....	95.3
Second cylinder.....	92.4
Third cylinder.....	88.6
Total indicated horsepower.....	276.3
Horsepower delivered (electrical horsepower).....	199.5
Mechanical efficiency (engine and generator combined)..... per cent..	72.2
Cubic feet standard gas per hour per indicated horsepower.....	59.8
Cubic feet standard gas per hour per electrical horsepower.....	82.9

Report of gas-engine test No. 5B.

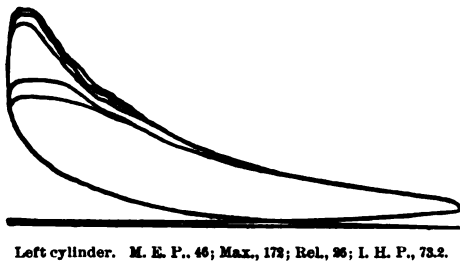
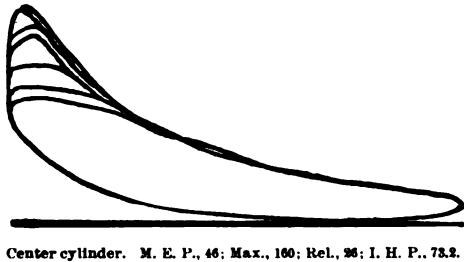
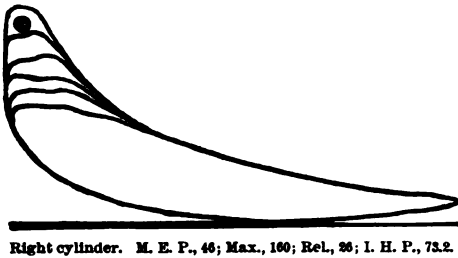
Recorded by R. W. Cummings and W. C. Weidmann, October 24, 25, 1904.

Producer test No. 5B.

Coal: General number, Montana No. 1; special number, G. P. 5B. Car initials and number, C. B. and Q. 33808.

Duration of test, in hours.....	4½
Revolutions per minute (mean).....	201.2
Explosions per minute (mean).....	100.6
Cubic feet gas per hour, by meter.....	17,694
Cubic feet standard gas per hour, (i. e., 62° F., 14.7 pounds pressure).....	17,455
Maximum pressure:	
First cylinder.....	169.3
Second cylinder.....	178.7
Third cylinder.....	160.7
Pressure at release:	
First cylinder.....	24.7
Second cylinder.....	24
Third cylinder.....	26
Mean effective pressure:	
First cylinder.....	47.3
Second cylinder.....	46.3
Third cylinder.....	47
Indicated horsepower:	
First cylinder.....	75.3
Second cylinder.....	73.7
Third cylinder.....	74.9
Total indicated horsepower.....	223.9

PRODUCER-GAS TESTS.		1187
Horsepower delivered (electrical horsepower).....		133.75
Mechanical efficiency (engine and generator combined).....per cent..		59.75
Cubic feet standard gas per hour per indicated horsepower.....		77.9
Cubic feet standard gas per hour per electrical horsepower.....		130.5



Indicator diagrams taken October 25, 1904, during gas-engine test No. 5B, on Montana No. 1 coal. Scale of spring, 80; revolutions per minute, 202.

NORTH DAKOTA No. 2.

GENERAL RESULTS.

The general results of tests of North Dakota No. 2 coal are as follows:

1403—No. 48, pt 3—06—14

Log of producer-gas test No. 10, North Dakota No. 2 coal, November 14, 15, 1904.

[Brown lignite from Cedar Coulee Coal Company, Williston, N. Dak.]

Time.	(Coal consumed by producer (pounds).	(Gas meter (cubic feet).	Temperature of gas (° F.).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.	Temperature of gas leaving producer (° C.).	Manometers at producer.	Temperatures (° C.).				Gas calorimeter.		B. T. U.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
				1.	2.	Watt meter.	Ammeter.	1.	2.				Volts.	Amperes.	(Gas entering (inches mercury).	(Gas leaving (inches water).	(Gas.	Inlet.		Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
8.30 a. m. a		5,175,550	48.0	85,636	2.3	0.4	294,050	22.0	5,666	31,966	241	b 624																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

a November 14. 8.30 a. m. to 5.50 p. m., barometer 29.75 inches; 5.50 to 7.50 a. m. November 15, barometer 29.77 inches.
b Full load was carried from 8.30 a. m. to 9.30 a. m. The load was then reduced to about 400 amperes.
c Until 1.10 p. m. the B. T. U. were determined from the analyses. After 1.10 p. m. a new calorimeter was used.

Log of producer-gas test No. 10, North Dakota No. 2 coal, November 14, 15, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Manometers at producer.		Gas calorimeter.					
		1.	2.		1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Ampers.	Temperature of gas leaving producer (° C.).	Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	B. T. U.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
6.20 p. m.	300	5,308,500	55.5	86,984	2.6	2.0	311,810	29.0	66,257		242	407				18.0	10.10	16.37	1,450	0.2	180.1	181.0
6.30 p. m.	300	5,312,030	55.5		2.7	2.0		30.0	68,257		242	407				17.0	10.10	16.38	1,500	.2	186.9	187.0
6.40 p. m.	300	5,315,580	55.0		2.6	2.0		25.0	70,262		241	417				16.8	10.15	16.31	1,440	.2	175.7	175.0
6.50 p. m.	300	5,319,180	55.0		2.6	2.0	313,520	26.0	72,263		240	417				15.8	10.07	16.28	1,500	.2	186.0	185.1
7.00 p. m.	300	5,322,750	54.5		2.6	1.8		30.0	74,260		240	417				15.7	10.10	16.10	1,520	.2	181.0	180.2
7.10 p. m.	300	5,326,240	54.5		2.6	1.9		30.0	76,272		239	417				15.5	10.09	16.07	1,515	.2	178.7	177.9
7.20 p. m.	300	5,330,760	54.5		2.6	2.0	315,380	30.0	78,297		240	417				15.3	10.09	16.08	1,600	.2	190.0	189.0
7.30 p. m.	300	5,333,280	54.5		2.6	1.9		30.0	80,322		241	417				15.4	10.10	16.09	1,565	.2	186.1	185.4
7.40 p. m.	300	5,336,750	55.0		2.6	1.8		22.5	82,349		240	417				15.2	10.10	16.07	1,570	.2	186.0	185.0
7.50 p. m.	300	5,340,370	54.5		2.6	2.0		23.0	84,375		240	417				15.7	10.11	16.18	1,575	.2	189.7	189.1
8.00 p. m.	300	5,343,990	54.5		2.6	1.9		29.0	86,365		241	417				15.4	10.50	16.41	1,590	.2	186.5	185.7
8.10 p. m.	300	5,347,510	55.0		2.7	1.9		25.0	88,424		238	417				15.8	10.40	16.40	1,610	.2	191.6	191.0

Log of producer-gas test No. 10, North Dakota No. 2 coal, November 14, 15, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Temperatures (° C.).				Gas calorimeter.		B. T. U.	
				1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Ampere.	13	14	Air entering (inches mer- cury).	Gas leaving (inches wa- ter).	17	18	19	20	21	22	23	Standardized.
1				5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
10.15 p. m.	300																						
10.20 p. m.				5,351,120	55.0	2.7	1.9	318,700	22.5	90,447		239	417			16.0	10.40	16.45	1,615	0.2	183.6	193.2	
10.30 p. m.																							
10.40 p. m.																							
10.50 p. m.				5,354,720	55.0	2.6	1.9		24.0	92,472	15,172	240	417	0.35	3.5	16.0	10.40	16.30	1,700	.2	198.8	198.4	
11 p. m.	300																						
11.10 p. m.				5,358,300	54.5	2.6	1.9		29.0	17,197	240	417				15.5	10.30	16.10	1,625	.2	186.9	186.1	
11.20 p. m.																							
11.30 p. m.																							
11.40 p. m.				5,362,000	54.0	2.7	2.0	320,260	24.0	19,225	240	417		.3	3.0	15.0	10.40	16.10	1,700	.2	192.1	191.0	
11.45 p. m.	300																						
11.50 p. m.				5,365,640	53.5	2.7	2.0		25.0	21,254	240	412											
12 p. m.																							
12.10 a. m. ^a				5,369,250	53.5	2.7	2.0		25.0	23,286	241	417											
12.15 a. m.	300																						
12.20 a. m.																							
12.30 a. m.				5,372,810	53.5	2.7	2.0		24.0	25,313	241	412		.25	2.5	15.0	10.40	16.20	1,700	.2	185.6	194.5	
12.40 a. m.																							
12.50 a. m.				5,376,350	53.5	2.7	2.0		24.0	27,336	240	417				15.0	10.40	16.10	1,700	.2	192.1	191.0	
1 a. m.	300																						
1.10 a. m.				5,380,000	53.5	2.7	1.9		29.0	29,350	240	417		.2	2.0	15.0	10.40	16.05	1,750	.2	196.0	194.9	
1.20 a. m.																							
1.30 a. m.	300			5,383,560	53.5	2.6	1.9	323,360	25.0	31,386	242	407				15.0	10.40	16.10	1,700	.2	192.1	191.0	
1.40 a. m.																							
1.50 a. m.				5,387,120	53.5	2.6	1.9		22.5	33,418	238	417				14.5	10.40	16.05	1,750	.2	196.0	194.4	

^a November 15. 7.50 a. m. to end of test, barometer 29.71.

Log of producer-gas test No. 10, North Dakota No. 2 coal, November 14, 15, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.	Temperatures of gas leaving producer (° C.).				Manometers at producer.		Gas calorimeter.				B. T. U.	
					1.	2.	Watt meter.	Ammeter.	1.	2.		Volts.	Amperes.	Air entering (inches mercury).	Gas leaving (inches water).	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
2 a. m.																							
2.10 a. m.	5,380,680	53.5			2.6	1.9		22.5		35,445	239	417				15.0	10.4	16.00	1,750	0.2	194.4	193.1	
2.15 a. m.	300																						
2.20 a. m.																							
2.30 a. m.	5,384,230	53.0	88,020	2.6	1.9		324,900	25.0		37,475	240	417		0.25	2.5	15.0	10.4	15.95	1,750	.2	192.8	191.6	
2.40 a. m.																							
2.45 a. m.	300															14.5	10.4	15.76	1,800	.2	190.3	188.6	
2.50 a. m.	5,387,790	53.0			2.6	1.9		24.0		39,508	240	417											
3 a. m.																							
3.10 a. m.	5,401,300	53.0			2.6	1.9		23.0		41,529	240	417				14.0	10.2	15.60	1,800	.2	192.8	191.0	
3.20 a. m.																							
3.30 a. m.	5,404,800	53.0			2.7	2.0	326,440	23.0		43,553	238	417		.2	2.75	14.0	10.3	15.60	1,850	.2	194.4	192.7	
3.40 a. m.	300															14.0	10.3	15.60	1,900	.2	196.6	197.9	
3.50 a. m.	5,408,280	53.0			2.7	1.9		31.0		45,571	240	417				14.0	10.3	15.50	1,850	.2	190.9	189.1	
4 a. m.																							
4.10 a. m.	5,412,810	53.0			2.7	1.9		23.0		47,587	240	417		.2	2.7								
4.15 a. m.	300																						
4.20 a. m.																14.0	10.3	15.30	1,800	.2	178.6	177.0	
4.30 a. m.	5,415,420	53.0	88,276	2.6	1.9			28.0		49,603	240	417											
4.40 a. m.																13.5	10.3	15.20	1,850	.2	179.8	177.8	
4.50 a. m.	5,419,020	53.0			2.6	1.9		23.0		51,627	238	417				13.5	10.3	15.00	1,950	.2	181.7	179.6	
5 a. m.	300																						
5.10 a. m.	5,422,710	53.0			2.6	1.9		23.0		53,640	240	417		.2	3.0	14.0	10.3	15.00	2,000	.2	186.5	184.8	
5.20 a. m.																							
5.30 a. m.	5,426,340	53.0			2.6	1.9		23.0		55,657	240	417				14.5	10.3	15.00	2,000	.2	186.5	185.0	
5.40 a. m.																							

Log of producer-gas test No. 10, North Dakota No. 2 coal, November 14, 15, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.	Manometers at producer.	Gas calorimeter.															
		Water meter (cubic feet).		Temperature of gas (° F.).	Water meter (cubic feet).	Ammeter.	1. 2.			Volts.	Amperes.	Temperature of gas leaving producer (° C.).	Manometers at producer.			Temperatures (° C.).			Gas calorimeter.						
		1.	2.				1.						2.	1.	2.	1.	2.	1.	2.	1.	2.	1.	2.	1.	2.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23			
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).			Gas calorimeter.	
		Gas meter (cubic feet).		Water meter (cubic feet).		Watt meter.		Ammeter.		1. 2.		Volts.		Amperes.											

Log of producer-gas test No. 10, North Dakota No. 2 coal, November 14, 15, 1964—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.			Load.	Temperatures of gas leaving producer (° C.).	Manometers at producer.			Temperatures (° C.).			Gas calorimeter.			B. T. U.	
				1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.			Amperes.	Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.			
1	8	8	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
1.40 p. m.																							
1.50 p. m.		5,517,400	67.0		2.7	1.9		25.0		5,927	242	402		0.3	3.0		24.0	10.8	21.40	900	0.2	191.3	196.5
2 p. m.																							
2.10 p. m.		5,521,280	66.5		2.7	1.9		25.0									23.0	10.9	21.20	900	.2	184.1	188.7
2.20 p. m.																							
2.30 p. m.	300	5,525,310	66.5		2.7	1.8	344,750	25.0		9,919	240	417					23.0	10.8	20.90	900	.2	170.5	174.7
2.50 p. m.		5,528,550	65.5		2.7	1.8		25.0		11,907	240	417											
3 p. m.																							
3.10 p. m.		5,533,800	66.0		2.7	1.8		20.0		13,904	242	412					22.0	10.7	19.60	1,000	.2	176.6	180.4
3.20 p. m.																							
3.30 p. m.		5,537,630	65.5	89,656	2.7	1.8		20.0		15,894	240	417					21.5	10.7	20.50	950	.2	184.9	188.3

PRODUCER-GAS TESTS.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
8.45 a. m. ^a	7.8	0.2	20.0	13.3	1.3	57.4	100.0	132.0
9.22 a. m.	7.6	.0	21.0	12.1	1.8	57.5	100.0	134.6
10.45 a. m.	8.0	.0	19.2	17.0	1.8	54.0	100.0	129.4
12.45 p. m.	9.8	.6	18.6	12.0	4.6	54.4	100.0	175.7
2.45 p. m.	9.0	.4	20.6	11.9	4.4	53.7	100.0	170.2
4.45 p. m.	8.8	.8	21.0	16.4	4.2	48.8	100.0	175.1
6.45 p. m.	9.4	.6	21.6	16.6	4.9	46.9	100.0	185.34
8.45 p. m.	9.0	.2	22.1	14.6	5.2	48.9	100.0	182.32
10.45 p. m.	8.8	.2	22.0	16.5	5.0	47.5	100.0	187.45
12.45 a. m. ^b	8.4	.0	22.0	15.6	5.6	48.4	100.0	190.71
2.45 a. m.	8.6	.2	23.0	17.5	3.8	46.9	100.0	181.64
4.45 a. m.	8.4	.2	22.2	16.1	5.0	48.1	100.0	186.75
6.45 a. m.	8.8	.2	21.6	18.9	3.3	47.2	100.0	176.3
8.45 a. m.	7.6	.0	20.2	13.9	6.6	51.7	100.0	189.16
10.45 a. m.	9.2	.2	19.6	11.9	8.5	50.6	100.0	200.34
12.45 p. m.	9.2	.2	20.4	12.4	8.4	49.4	100.0	203.6
1.45 p. m.	9.4	.0	20.2	7.0	8.2	55.2	100.0	182.19

^a November 14. ^b November 15.

Producer-gas test No. 10, ^a North Dakota No. 2 coal.

[Recorded by M. H. Mount and R. E. Peshak, November 14, 15, 1904.]

1. Duration of test, in hours..... 30

AVERAGE TEMPERATURE, ° F.

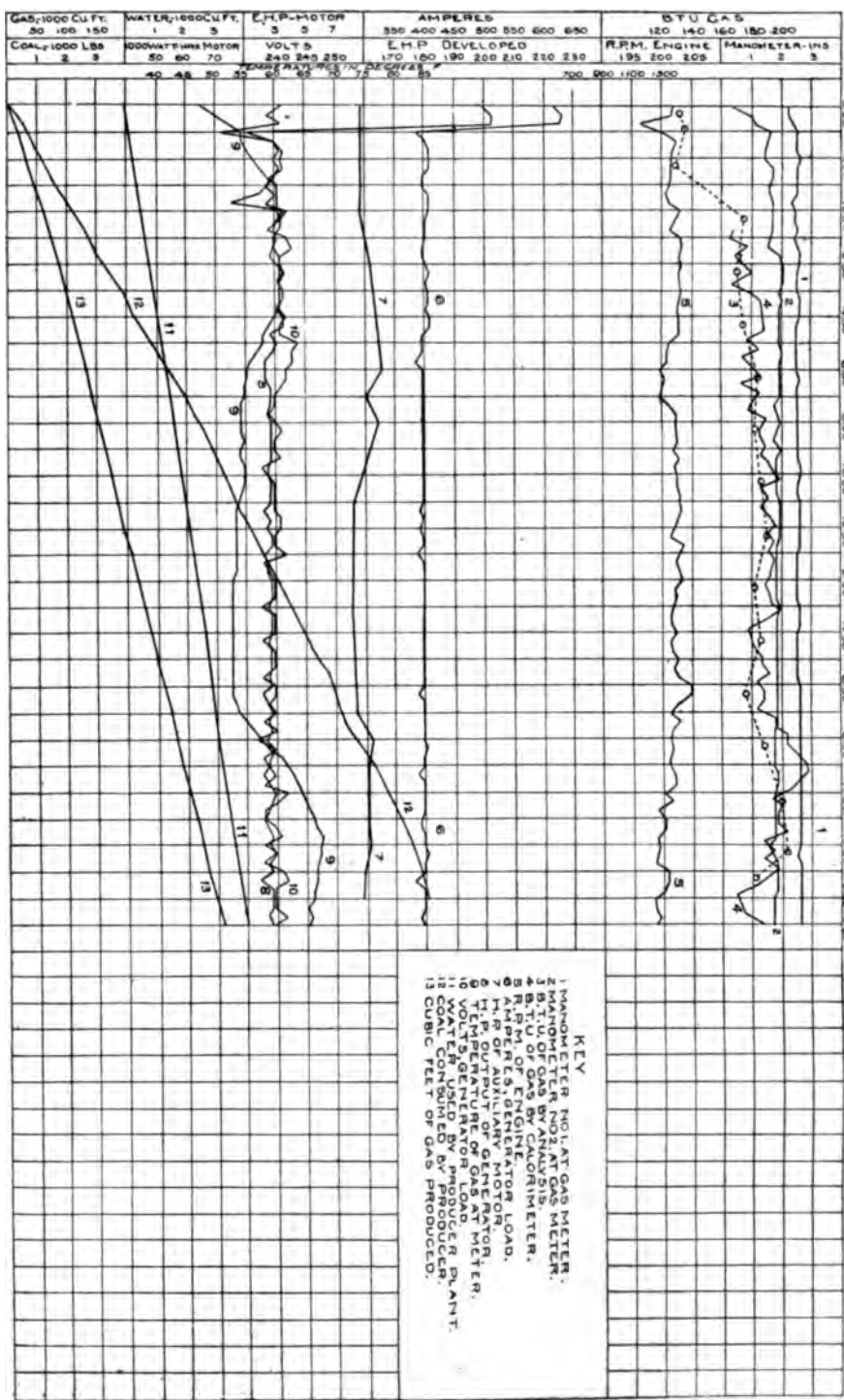
2. Gas leaving producer.....
3-6. (See footnote on p. 1027.)

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

7. Total steam used by producer.....	pounds..	4,500
8. Steam used by producer per hour.....	do.....	150
9. Equivalent in pounds of coal per hour.....		50
10. Equivalent in pounds of dry coal per hour.....		30
11. Equivalent in pounds of combustible per hour.....		26.8
12. Average horsepower required to drive auxiliary machinery.....		9.07
13. Total water used in scrubber and tar extractor.....	cubic feet..	3,886.5
14. Cubic feet of water per hour per horsepower of producer plant.....		.518
15. Cubic feet of water per 1,000 cubic feet of gas produced.....		11.22

^aGas-producer hopper leaked.

FIG. 134.-(Graphical log sheet, producer-gas test, North Dakota No. 2 coal.



OPERATIONS OF THE COAL-TESTING PLANT.

COAL CONSUMED IN PRODUCER.

16. Total coal consumed.....	pounds..	13,800
17. Moisture in coal.....	per cent..	39.56
18. Total dry coal consumed.....	pounds..	8,340
19. Refuse from dry coal.....	per cent..	10.53
20. Total refuse from coal.....	pounds..	878
21. Total combustible consumed.....	do....	7,462

COAL PER HOUR.

22. Coal consumed in producer.....	pounds..	460
23. Dry coal consumed in producer.....	do....	278
24. Combustible consumed in producer.....	do....	249
25. Equivalent coal used by producer plant.....	do....	510
26. Equivalent dry coal used by producer plant.....	do....	308
27. Equivalent combustible used by producer plant.....	do....	275.8

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired.....	pounds..	12
29. Dry coal.....	do....	7.23
30. Combustible.....	do....	6.48

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	6,802
32. Per pound of dry coal.....	11,255
33. Per pound of combustible.....	12,600
34. From coal as fired, per hour.....	3,129,000
35. From dry coal, per hour.....	3,129,000
36. From combustible, per hour.....	3,129,000

GAS PRODUCED. CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	346,400
38. Per hour.....	11,550
39. Per pound coal consumed in producer.....	25.15
40. Per pound dry coal consumed in producer.....	41.53
41. Per pound combustible consumed in producer.....	46.42
42. Per pound equivalent coal used by producer plant.....	22.68
43. Per pound equivalent dry coal used by producer plant.....	37.50
44. Per pound equivalent combustible used by producer plant.....	41.88

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	188.5
46. Per pound dry coal burned in producer.....	7,830
47. Per hour per brake horsepower.....	13,770

PRODUCER-GAS TESTS.

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AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	125.1
49. Electrical horsepower developed at switch board.....	134.2
50. Brake horsepower available for outside purposes.....	147.3
51. Brake horsepower developed at engine.....	158

EFFICIENCIES.

52. Of conversion and cleaning gas.....	.696
53. Of producer plant.....	.624

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	3.67	2.22	1.99
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	3.42	2.07	1.86
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	3.13	1.89	1.69
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	2.91	1.76	1.58
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	4.07	2.46	2.20
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	3.80	2.29	2.05
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purpose.....	3.47	2.09	1.88
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	2.23	1.95	1.74

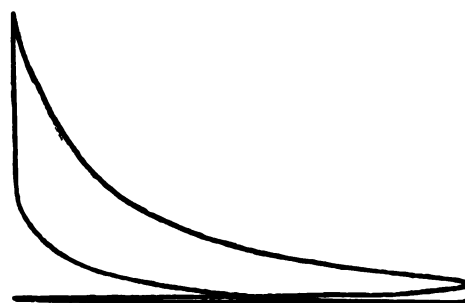
^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

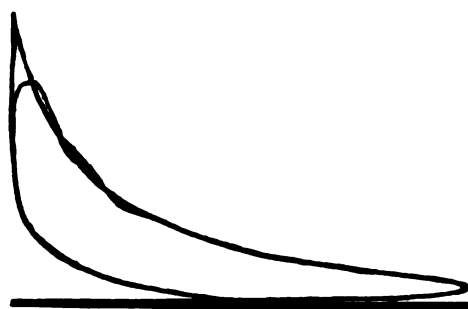
62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	39.56	Carbon dioxide (CO ₂).....	8.69
Volatile matter.....	27.78	Oxygen (O ₂).....	.23
Fixed carbon.....	26.30	Carbon monoxide (CO).....	20.90
Ash.....	6.36	Hydrogen (H ₂).....	14.33
	100.00	Methane (CH ₄).....	4.85
Sulphur.....	.93	Nitrogen (N ₂).....	51.00
			100.00

The test was begun on full load, but owing to the difficulties encountered in a previous test of a lignite it was deemed wise to reduce the load. This was done after the first hour of the run, and the first hour has, consequently, been thrown out in making up the report of the test. The producer behaved so well that it is probable that full load might have been carried for the entire test without difficulty. However, as the test was well under way before this point was fully settled, it was decided to carry the run through on two-thirds load.

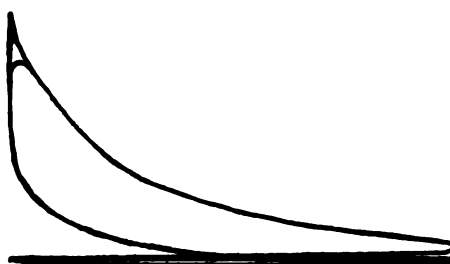
North Dakota No. 2 is a brown lignite. It is an ideal gas-producer fuel but for its tendency to clinker. It yielded a rich gas, which was very uniform throughout the test. Fifty gallons of tar were extracted. This tar was yellow and sticky and not at all like that from bituminous coal. The bed had to be carried deeper than for soft coal and had to be poked frequently to prevent the formation of clinkers. After thirty hours' continuous run the bed was in good condition, and



Right cylinder. M. E. P., 38; Max., 218; Rel., 16; I. H. P., 60.4.



Center cylinder. M. E. P., 41; Max., 220; Rel., 22; I. H. P., 65.2.



Left cylinder. M. E. P., 38; Max., 190; Rel., 16; I. H. P., 60.4.

Indicator diagrams taken November 14, 1904, during gas-engine test No. 10 on North Dakota No. 2 lignite. Scale of spring, 80; revolutions per minute, 202.

the test could have been continued or a new run begun without renewing the producer bed. The heat value of the gas (188.5 B. T. U.) was higher than that from any other fuel tested.

A little difficulty was experienced with the ignition setting of the engine, as this gas required a later spark than the gas from an ordinary coal.

The values for items 7, 8, and 9 were computed by comparison with the values obtained by the boiler division of the testing plant from "North Dakota No. 1."

PRODUCER-GAS TESTS.

1201

GAS ENGINE.

Following are results of tests by gas engine:

Report of gas-engine test No. 10.

Recorded by R. W. Cummings and W. C. Weidmann, November 14, 15, 1904.

Producer test No. 10.

Coal: General number, North Dakota No. 2; special number, G. P. 10. Car initials and number, Great Northern 9992.

Duration of test, in hours.....	30
Revolutions per minute (mean).....	201.7
Explosions per minute (mean).....	100.8
Cubic feet gas per hour, by meter.....	11,454
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	11,529
Maximum pressure:	
First cylinder.....	201
Second cylinder.....	204
Third cylinder.....	200.5
Pressure at release:	
First cylinder.....	18.8
Second cylinder.....	23.3
Third cylinder.....	19.8
Mean effective pressure:	
First cylinder.....	40.4
Second cylinder.....	43
Third cylinder.....	38.15
Indicated horsepower:	
First cylinder.....	64.37
Second cylinder.....	68.1
Third cylinder.....	60.6
Total indicated horsepower.....	193
Horsepower delivered (electrical horsepower).....	134.2
Mechanical efficiency (engine and generator combined)..... per cent..	69.5
Cubic feet standard gas per hour per indicated horsepower.....	59.7
Cubic feet standard gas per hour per electrical horsepower.....	85.9

TEXAS No. 1.

GENERAL RESULTS.

The general results of tests of Texas No. 1 coal are tabulated as follows:

Log of producer-gas test No. 11, Tests No. 1 coal, November 21, 22, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Temperature of gas (° F.).		Water meter (cubic feet).	Manometers at gas meter (inches water).	Auxiliary motors.		Speed counters on gas engine.		Load.	Temperature of gas leaving producer (° C.).	Manometers at producer.		Temperatures (° C.).				Gas calorimeter.		B. T. U.		
		(Gas meter (cubic feet)).	(Gas meter (cubic feet)).			Watt meter.	Ammeter.	1.	2.			Volts.	Ampers.	Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Outlet.	(cubic centimeters of water collected).		(cubic feet of gas).	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2.10 p. m.		5,647,790	63.5		2.5	1.1		28.0	28,052		242	624	0.5	6.0								
2.15 p. m.	300																					
2.30 p. m.		5,653,510	64.0		2.5	1.2		27.0	30,054		242	619										
2.50 p. m.		5,659,140	64.0		2.5	1.1		32.0	32,056		240	619										
2.52 p. m.							368,420															
3 p. m.	300																					
3.10 p. m.		5,665,000	63.0		2.5	1.1		28.0	34,037		242	518	.5	7.0								
3.30 p. m.	300	5,670,990	63.0		2.5	1.3		29.0	36,033		244	528										
3.50 p. m.		5,665,980	63.0	102,121	2.5	1.5		24.0	38,043		244	518										
3.52 p. m.							370,190															
4 p. m.	300																					
4.10 p. m.		5,680,540	63.0		2.5	1.5		26.0	40,058		236	528	.3	3.0								
4.30 p. m.	300	5,685,190	63.0		2.5	1.5		26.0	42,065		240	518	.4	4.5								
4.50 p. m.		5,689,950	61.0		2.5	1.2		26.0	44,072		240	518										
4.52 p. m.							371,840															
5 p. m.	300																					
5.10 p. m.		5,694,700	60.0		2.5	1.2		29.0	46,082		240	518	.5	6.0								
5.30 p. m.	300	5,699,300	60.0		2.5	1.2		26.0	48,095		240	518										
5.50 p. m.		5,704,070	59.0	102,359	2.5	1.2		25.0	50,094		240	518	.4	4.5								
5.52 p. m.							373,580															
6 p. m.	300																					
6.10 p. m.		5,709,100	58.0		2.5	1.2		26.0	52,100		240	619	.5	5.0								
6.30 p. m.	300	5,714,140	58.0		2.5	1.0		28.0	54,097		245	619	.4	5.0								
6.50 p. m.		5,719,440	58.0		2.5	1.1		26.0	56,093		240	619										
6.52 p. m.																						
7.05 p. m.	300																					

^a Load reduced from 3.10 p. m. to 6.10 p. m.

Log of producer-gas test No. 11, Texas No. 1 coal, November 21, 22, 1904—Continued.

Time.	(Coal consumed by producer (pounds).)	(Gas meter (cubic feet).)	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).	Auxiliary motors.		Speed counters on gas engine.		Load.	Temperatures of gas leaving producer (° C.).		Manometers at producer.		Temperatures (° C.).		Gas calorimeter.		B. T. U.			
						Watt meter.	Ammeter.	1.	2.		Volts.	Amperes.	14	15	16	(Gas leaving in inches water).	(Air entering in inches water).	(Gas, Inlet.		Outlet.	Cubic centimeters of water collected.	(Cubic feet of gas.
7.10 p. m.	5,724,900	58.0	2.5	1.0	29.0	58,087	240	619	0.5	6.0	17	18	19	20	21	22	23	24	25			
7.30 p. m.	5,730,300	58.0	2.5	1.0	25.0	60,083	240	619	.5	5.5	17	18	19	20	21	22	23	24	25			
7.50 p. m.	5,736,210	58.0	2.5	1.0	30.0	62,085	239	619			17	18	19	20	21	22	23	24	25			
7.52 p. m.					377,120						17	18	19	20	21	22	23	24	25			
8 p. m.	300	102,590									17	18	19	20	21	22	23	24	25			
8.10 p. m.	5,741,950	58.0	2.5	.9	30.0	64,085	240	619	.6	6.0	17	18	19	20	21	22	23	24	25			
8.30 p. m.	5,747,740	58.0	2.5	.9	28.0	66,102	239	619	.6	6.0	17	18	19	20	21	22	23	24	25			
8.50 p. m.	5,753,200	58.0	2.5	1.0	26.0	68,125	241	619			17	18	19	20	21	22	23	24	25			
8.52 p. m.					378,840						17	18	19	20	21	22	23	24	25			
9 p. m.	300										17	18	19	20	21	22	23	24	25			
9.10 p. m.	5,758,500	58.0	2.5	1.0	25.0	70,142	240	619	.6	6.0	17	18	19	20	21	22	23	24	25			
9.30 p. m.	5,763,990	58.0	2.5	1.0	30.0	72,159	240	619			17	18	19	20	21	22	23	24	25			
9.50 p. m.	5,769,550	58.0	2.5	1.0	30.0	74,168	241	619	.6	6.0	17	18	19	20	21	22	23	24	25			
9.52 p. m.					380,500						17	18	19	20	21	22	23	24	25			
10 p. m.	300										17	18	19	20	21	22	23	24	25			
10.10 p. m.	5,774,800	58.0	2.5	1.1	29.0	76,185	238	614	.6	6.0	17	18	19	20	21	22	23	24	25			
10.30 p. m.	5,780,120	58.0	2.5	1.1	24.0	78,203	240	614			17	18	19	20	21	22	23	24	25			
10.50 p. m.	5,785,320	58.5	2.5	1.1	22.5	80,218	240	609	.6	6.0	17	18	19	20	21	22	23	24	25			
10.52 p. m.					382,350						17	18	19	20	21	22	23	24	25			
11 p. m.	300										17	18	19	20	21	22	23	24	25			
11.10 p. m.	5,790,600	58.5	2.5	1.0	25.0	82,237	239	619			17	18	19	20	21	22	23	24	25			
11.30 p. m.	5,796,050	58.5	2.5	1.0	47.5	84,245	238	634			17	18	19	20	21	22	23	24	25			
11.50 p. m.	5,801,800	58.0	2.4	.8	22.0	86,259	242	619			17	18	19	20	21	22	23	24	25			
11.52 p. m.					384,450						17	18	19	20	21	22	23	24	25			
12.10 a. m. ^a	5,807,540	57.5	2.5	1.0	20.0	88,275	240	609	.3	3.5	17	18	19	20	21	22	23	24	25			

November 22. 8.10 a. m. to 8.25 a. m. tar extractor was by-passed to clear out the tar.

^a November 22. 8.10 a. m. to 8.25 a. m. tar extractor was by-passed to clear out the tar.

Lay of producer-gas test No. 11, Texas No. 1 coal, November 21, 22, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Manometers at gas meter (inches water).		Auxiliary motors. Speed counters on gas engine.		Gas calorimeter.		Temperatures (° C.).		Manometers at producer.	Load.		Temperatures of gas leaving producer (° C.).		Water.		Cubic centimeters of water collected.		Cubic feet of gas.	B. T. U.				
		Temperature of gas (° F.).	Water meter (cubic feet).	1.	2.	Watt meter.	Ammeter.	1.	2.		Volts.	Amperes.	Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Outlet.	As read.		Standardized.				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
12.15 a. m.	300	5,813,200	57.0		2.5	1.0		25.0	90,288		240	619		0.4	4.5									
12.30 a. m.																								
12.45 a. m.	300	5,818,880	57.0		2.5	1.0		35.0	92,302		240	624												
12.50 a. m.							388,100																	
12.52 a. m.																								
1.10 a. m.	300	5,824,340	57.0		2.5	1.0		34.0	94,323		241	619		.2	3.0									
1.15 a. m.																								
1.30 a. m.	300	5,829,800	57.0		2.5	1.0		37.0	96,340		239	629		.5	6.0									
1.45 a. m.																								
1.50 a. m.	300	5,835,210	57.0	103,368	2.5	1.0		31.0	98,359		240	609												
1.52 a. m.							388,300																	
2.10 a. m.	300	5,841,810	57.0		2.5	.8		31.0	370		240	600												
2.15 a. m.																								
2.20 a. m.	300	5,846,500	57.0		2.5	.8		31.0	2,379		240	609												
2.45 a. m.	300																							
2.50 a. m.		5,852,000	57.0		2.5	.8	390,750	30.0	4,400		240	609												
3.10 a. m.		5,857,330	57.0		2.5	1.0		32.0	6,418		240	619												
3.15 a. m.	300						315 a. m.																	
3.30 a. m.		5,862,650	57.0		2.5	.8		37.0	8,437		240	619		.4	4.5									
3.45 a. m.	300																							
3.50 a. m.		5,868,040	57.0	103,660	2.5	.8		35.0	10,455		239	619												
4.10 a. m.		5,873,610	57.0		2.5	1.0		40.0	12,468		239	619												
4.15 a. m.	300																							
4.30 a. m.		5,879,170	56.5		2.5	.8		36.0	14,485		239	619		.5	5.5									
4.45 a. m.	300																							
4.50 a. m.		5,884,500	56.0		2.5	1.0		39.0	16,500		240	609												

Log of producer-gas test No. 11, Texas No. 1 coal, November 21, 22, 1904—Continued.

Time.	Gas meter (cubic feet).	Temperature of gas (° F.).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.	Manometers at producer.		Temperatures (° C.).		Gas calorimeter.		B. T. U.					
			Water meter (cubic feet).	Gas meter (cubic feet).	Watt meter.	Ammeter.	1.	2.		Volts.	Amperes.	Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.		Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	19	20	21	22	23
5.10 a. m.		5,890,190	56.0		2.4	1.0		34.0	18,512		239	619		0.5	5.0						
5.15 a. m.	300																				
5.30 a. m.		5,895,750	56.0		2.5	1.0		37.0	20,516		220	a 487									
5.45 a. m.	300																				
5.50 a. m.		5,900,960	56.0	104,013	2.4	.5	397,490	27.0	22,538		240	619									
6.10 a. m.		5,906,900	56.0		2.5	.9		39.0	24,562		239	619									
6.15 a. m.	300																				
6.30 a. m.		5,912,900	57.0		2.5	.9		33.0	26,577		239	619									
6.50 a. m.		5,918,900	56.0		2.5	.9	399,800	25.0	28,565		237	619									
7 a. m.	300																				
7.10 a. m.		5,924,810	56.0		2.5	.9		29.0	30,611		241	624									
7.30 a. m.	300	5,931,750	56.0		2.5	.9		28.0	.....	b 202.0	241	619		.6	8.0						
7.50 a. m.		5,936,720	57.0	104,284	2.5	.9	401,980	30.0	33,600	b 202.0	239	619									
8 a. m.	300																				
8.10 a. m.		5,942,690	58.0		2.5	.9		27.0	35,617		240	619									
8.30 a. m.	300	5,948,600	61.0		2.5	.8		5.0	37,637		241	619									
8.50 a. m.		5,954,750	64.0		2.5	.4	403,650	32.0	39,657		240	629									
9 a. m.	300																				
9.10 a. m.		5,959,780	66.0		2.5	.4		29.0	41,677		239	619		.7	7.5						
9.30 a. m.	300	5,967,050	67.0		2.0	.9		38.0	43,672		241	629									
9.50 a. m.		5,972,850	67.5		2.5	.6	406,050	35.0	45,698		239	644		.7	8.0						
10 a. m.	300																				
10.10 a. m.		5,978,600	68.0	104,591	2.5	.5		45.0	47,720		238	624		.7	7.5						
10.30 a. m.	300	5,984,190	69.0		2.5	.6		30.0	49,744		240	619		.7	7.5						
10.50 a. m.		5,989,650	69.0		2.5	.6	408,250	30.0	51,766		239	619									
11 a. m.	300																				

a From 5.25 a. m. to 5.50 a. m. load was reduced to about 500 amperes.
b Hand counter used.

a From 5.25 a. m. to 5.50 a. m. load was reduced to about 500 amperes.

b Hand counter used.

Log of producer-gas test No. 11, Texas No. 1 coal, November 21, 22, 1904—Continued.

Time.	(Coal consumed by producer (pounds).)		(Gas meter (cubic feet).)		Temperature of gas (°F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (°C.).		Manometers at producer.		Gas calorimeter.				B. T. U.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23			

PRODUCER-GAS TESTS.

OPERATIONS OF THE COAL-TESTING PLANT.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.	B. T. U. standard- ized.
9.55 a. m. ^a	7.4	0.0	21.6	10.9	4.0	56.1	100.0	156.6	155.8
12.05 p. m.	8.6	.0	20.4	11.7	4.6	54.7	100.0	161.0	164.3
1 p. m.	8.4	.2	19.4	9.0	5.4	57.6	100.0	185.4	189.3
2 p. m.	7.4	.6	18.6	7.5	8.6	57.3	100.0	172.6	176.7
3 p. m.	9.2	.4	16.6	4.4	8.9	60.5	100.0	168.0	171.7
4 p. m.	9.4	.0	17.6	11.5	5.1	56.4	100.0	155.8	159.3
5 p. m.	9.8	.2	18.4	12.0	6.6	53.0	100.0	176.2	179.2
6 p. m.	10.4	.0	16.0	9.5	8.3	55.2	100.0	174.3	178.5
7 p. m.	9.6	.2	16.8	4.5	4.2	64.7	100.0	119.0	121.5
8.20 p. m.	9.6	.0	13.8	9.5	8.3	58.8	100.0	169.6	171.7
9 p. m.	9.6	1.0	13.6	8.2	8.2	59.4	100.0	163.3	165.3
10 p. m.	9.8	.6	15.4	11.4	6.6	56.2	100.0	163.7	165.7
11 p. m.	9.8	.2	17.0	12.3	6.4	54.3	100.0	170.3	172.4
12 p. m.	11.0	.4	15.8	11.6	5.8	55.4	100.0	157.3	159.4
1 a. m. ^b	10.6	.2	16.0	12.3	7.0	53.9	100.0	173.2	175.2
2 a. m.	11.6	.0	14.8	8.2	8.2	57.2	100.0	167.5	169.3
3 a. m.	11.4	.4	16.0	13.3	6.9	52.0	100.0	178.6	180.3
4 a. m.	11.4	.2	14.2	12.0	6.0	56.2	100.0	155.2	156.8
5 a. m.	11.4	.4	14.6	8.8	7.6	57.2	100.0	162.5	164.1
6 a. m.	11.4	.4	14.8	11.2	7.0	55.2	100.0	165.2	166.6
7 a. m.	11.8	.2	13.4	11.3	8.3	55.0	100.0	174.5	176.0
8 a. m.	12.0	.0	13.8	13.0	6.5	54.7	100.0	162.6	163.7
9 a. m.	11.0	.0	12.4	11.3	9.0	56.3	100.0	178.5	180.8
10 a. m.	11.8	.0	12.0	10.4	9.1	56.7	100.0	175.0	179.9
11 a. m.	12.0	.2	13.0	8.4	9.0	57.4	100.0	170.5	176.2
12 m.	11.4	.0	13.8	9.9	9.0	55.9	100.0	178.5	184.8
1 p. m.	12.6	.0	12.6	12.3	7.8	54.7	100.0	169.8	176.5
2 p. m.	12.0	.0	14.2	11.5	7.7	54.6	100.0	171.6	178.5
3 p. m.	11.8	.4	13.4	10.7	7.7	56.0	100.0	166.0	172.8

^a November 21.^b November 22.*Producer-gas test No. 11,^a Texas No. 1 coal.*

[Recorded by C. W. Weidmann and R. W. Cummings, November 21, 22, 1904.]

1. Duration of test, in hours 21.67

AVERAGE TEMPERATURE, ° F.

2. Gas leaving producer.

3-6. (See footnote on p. 1027.)

^a Gas-producer hopper leaked.

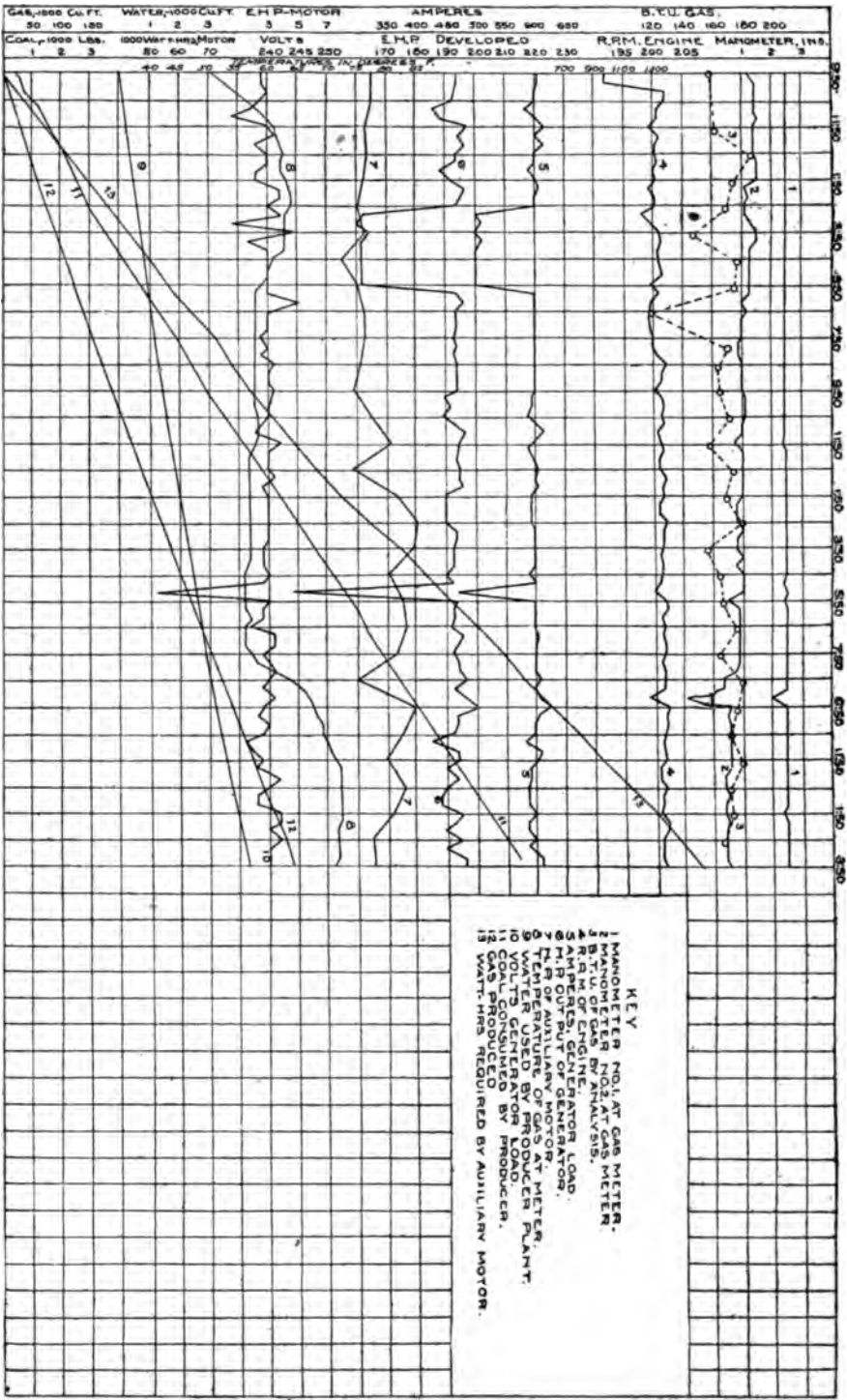


Fig. 125.—Graphical log sheet, producer-gas test, Texas No. 1 coal.

OPERATIONS OF THE COAL-TESTING PLANT.

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

9. Equivalent in pounds of coal per hour.....	70
10. Equivalent in pounds of dry coal per hour.....	46.5
11. Equivalent in pounds of combustible per hour.....	39.3
12. Average horsepower required to drive auxiliary machinery.....	11
13. Total water used in scrubber and tar extractor..... cubic feet..	3,320.9
14. Cubic feet of water per hour per horsepower of producer plant.....	.614
15. Cubic feet of water per 1,000 cubic feet of gas produced.....	9.14

COAL CONSUMED IN PRODUCER.

16. Total coal consumed..... pounds..	12,800
17. Moisture in coal..... per cent..	33.50
18. Total dry coal consumed..... pounds..	8,510
19. Refuse from dry coal..... per cent..	15.58
20. Total refuse from coal..... pounds..	1,327
21. Total combustible consumed..... do....	7,183

COAL PER HOUR.

22. Coal consumed in producer..... pounds..	590
23. Dry coal consumed in producer..... do....	393
24. Combustible consumed in producer..... do....	332
25. Equivalent coal used by producer plant..... do....	660
26. Equivalent dry coal used by producer plant..... do....	439.5
27. Equivalent combustible used by producer plant..... do....	371.3

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired..... pounds..	15.36
29. Dry coal..... do....	10.22
30. Combustible..... do....	8.64

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	7,267
32. Per pound of dry coal.....	10,928
33. Per pound of combustible.....	12,945
34. From coal as fired, per hour.....	4,295,000
35. From dry coal, per hour.....	4,295,000
36. From combustible, per hour.....	4,295,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	363,654
38. Per hour.....	16,800
39. Per pound coal consumed in producer.....	28.4
40. Per pound dry coal consumed in producer.....	42.7
41. Per pound combustible consumed in producer.....	50.6
42. Per pound equivalent coal used by producer plant.....	25.5
43. Per pound equivalent dry coal used by producer plant.....	38.2
44. Per pound equivalent combustible used by producer plant.....	45.3

PRODUCER-GAS TESTS.

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BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot	169.7
46. Per pound dry coal burned in producer	7,260
47. Per hour per brake horsepower	12,230

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes	187
49. Electrical horsepower developed at switch board	198
50. Brake horsepower available for outside purposes	220
51. Brake horsepower developed at engine	233

EFFICIENCIES.

52. Of conversion and cleaning gas	.664
53. Of producer plant	.590

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes	3.16	2.10	1.78
55. Pounds consumed in producer per electrical horsepower developed at switch board	2.98	1.99	1.68
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes	2.68	1.79	1.51
57. Pounds consumed in producer per brake horsepower ^a developed at engine	2.54	1.69	1.43
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	3.53	2.35	1.99
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board	3.34	2.22	1.88
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes	3.00	2.00	1.69
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine	2.83	1.89	1.60

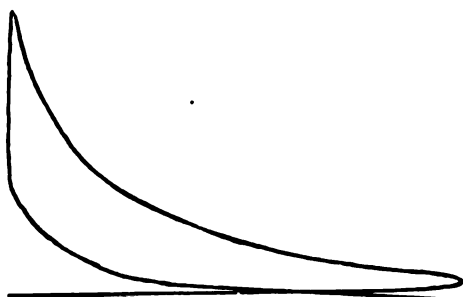
^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture	33.50	Carbon dioxide (CO ₂)	11.10
Volatile matter	32.34	Oxygen (O ₂)	.22
Fixed carbon	23.80	Carbon monoxide (CO)	14.43
Ash	10.36	Hydrogen (H ₂)	10.54
	100.00	Methane (CH ₄)	7.48
		Nitrogen (N ₂)	56.23
Sulphur	.63		100.00

There seemed to be some difficulty in getting the proper ignition setting. Although full load was carried for a few hours, it had to be reduced at 2.50 p. m. for a little over three hours. At 6 p. m. full load was resumed and with the exception of a few minutes this load was easily carried to the end of the test. The report is based on the records obtained between 6.10 p. m. November 21 and 3.50 p. m. November 22, a run of 21.67 hours.

Texas No. 1 is a brown lignite strongly resembling that previously tested from North Dakota. The gas from it was not so rich as that from the North Dakota



Right cylinder. M. E. P., 44; Max., 240; Rel., 24; I. H. P., 69.6.



Center cylinder. M. E. P., 55; Max., 180; Rel., 32; I. H. P., 86.9.



Left cylinder. M. E. P., 63; Max., 176; Rel., 30; I. H. P., 99.3

Indicator diagrams taken November 21, 1904, during gas-engine test No. 11, on Texas No. 1 coal. Revolutions per minute, 200.7.

lignite, but it was higher in heat units than is the gas obtained from ordinary soft coal. The lignite was more difficult to handle in the producer than bituminous coal, but by frequent poking and by supplying the right amount of air to the producer the bed was kept in good condition, and at the end of the thirty-hour test it was possible to break up the clinkers in the bed, requiring the removal of only a small amount of ash before beginning a new test. This lignite yielded a large amount (150 gallons) of tar of the same kind as the lignite previously tested from North Dakota. As a producer fuel it is better than many grades of bituminous coal.

Eleven per cent of the lignite fired was taken for the value of item 9.

Two sets of indicator cards are shown. The first set was taken during the period when the engine was carrying reduced load. The second set was taken on full load.

GAS ENGINE.

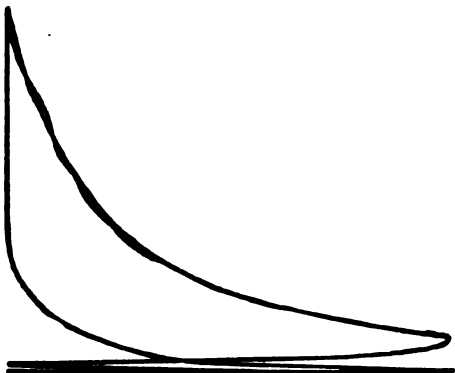
Following are results of tests by gas engine:

Report of gas-engine test No. 11.

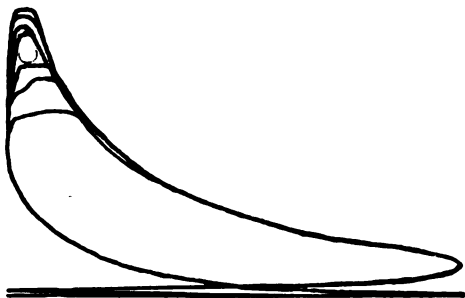
Recorded by R. W. Cummings and W. C. Weidmann, November 21, 22, 1904.

Producer test No. 11.

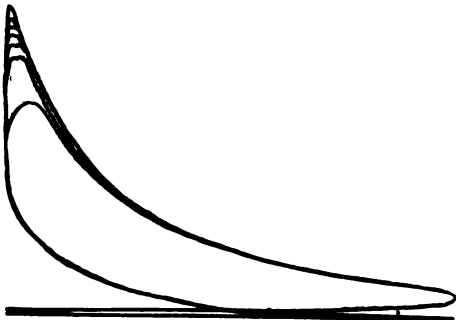
Coal: General number, Texas No. 1: special number, G. P. 11. Car initials and number, Mo. Pac. 27288.



Right cylinder. M. E. P., 61; Max., 290; Rel., 32; I. H. P., 96.8.



Center cylinder. M. E. P., 59; Max., 220; Rel., 34; I. H. P., 93.6.



Left cylinder. M. E. P., 50; Max., 250; Rel., 28; I. H. P., 79.4.

Indicator diagrams taken November 22, 1904, during gas-engine test No. 11, on Texas No. 1 coal. Revolutions per minute, 201.5.

Duration of test, in hours.....	21½
Revolutions per minute (mean).....	201.5
Explosions per minute (mean).....	100.7
Cubic feet gas per hour, by meter.....	16,940
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	16,800

Maximum pressure:	
First cylinder.....	274
Second cylinder.....	253
Third cylinder.....	248.8
Pressure at release:	
First cylinder.....	27.9
Second cylinder.....	30.7
Third cylinder.....	27.8
Mean effective pressure:	
First cylinder.....	56.6
Second cylinder.....	58.3
Third cylinder.....	55
Indicated horsepower:	
First cylinder.....	88.85
Second cylinder.....	92.6
Third cylinder.....	87.3
Total indicated horsepower.....	268.75
Horsepower delivered (electrical horsepower).....	198
Mechanical efficiency (engine and generator combined).....per cent..	73.7
Cubic feet standard gas per hour per indicated horsepower.....	62.5
Cubic feet standard gas per hour per electrical horsepower.....	84.8

TEXAS No. 2.

GENERAL RESULTS.

The general results of tests of Texas No. 2 coal are shown in the following table:

Log of producer-gas test No. 18, Texas No. 2 coal, December 21, 22, 1904.
[Lignite from Hoyte, Tex., Consumers' Lignite Coal Company, Dallas, Tex.]

Time.	Coal consumed by producer (pounds).	Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Gas calorimeter.				B. T. U.	
		Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Gas calorimeter.				B. T. U.	
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
8.50 a. m. ^a		8,856,500	49.0		2.	0.3	830,900			0,000	240	624	250	0.4	4.5	10.5	4.8	19.0	570	0.2	160.3	157.3	
9 a. m.		8,862,280	51.0		2.3	.5				2,040	238	629				10.5	4.8	19.0	570	0.2	160.3	157.3	
9.10 a. m.																							
9.25 a. m.																							
9.30 a. m.	300	8,867,500	53.0		2.3	.6				4,080	240	634				10.5	5.0	12.5	980	.2	145.6	143.4	
9.50 a. m.		8,872,400	60.0		2.4	.8	831,000			6,120	239	624	210	.5	5.5	12.0	5.2	22.3	430	.2	145.6	144.3	
10.10 a. m.		8,877,350	62.0		2.4	.8				8,156	239	629				12.0	5.2	22.3	430	.2	145.6	144.3	
10.15 a. m.	300																						
10.30 a. m.		8,882,400	62.5		2.4	.9				10,195	238	629				12.5	6.0	23.5	410	.2	142.1	140.6	
10.50 a. m.		8,887,560	63.5		2.4	.9	833,000			12,234	241	624	220	.5	4.0	13.8	5.2	18.8	620	.2	166.6	165.6	
11 a. m.																							
11.10 a. m.		8,892,000	64.0		2.4	.9				14,274	240	624				14.5	5.2	18.5	610	.2	158.7	157.9	
11.30 a. m.		8,897,700	66.0		2.4	.9				16,314	239	624				16.0	5.3	18.8	610	.2	162.7	162.8	
11.45 a. m.	300																						
11.50 a. m.		8,902,580	68.0		2.4	1.0	835,000			18,351	239	624	250										
12.10 p. m.		8,907,300	69.0		2.4	1.0				20,385	238	629											
12.30 p. m.	300	8,912,100	70.0		2.4	1.0				22,421	237	639		.4	4.0	23.0	5.5	19.8	610	.2	173.0	177.5	
12.50 p. m.		8,917,900	71.0		2.4	1.0	857,000			24,459	241	624	200			23.0	5.3	20.5	600	.2	180.8	185.4	
1.10 p. m.		8,921,650	69.0		2.4	1.1				26,465	240	624											
1.15 p. m.	300																						
1.30 p. m.		8,924,150	69.0		2.4	1.0	857,910			0,000	241	634		.4	4.0								
1.40 p. m.																21.0	5.1	15.3	830	.2	167.8	170.8	
1.50 p. m.		8,929,420	70.0		2.4	1.0				2,038	238	634	200			20.8	5.3	15.9	800	.2	168.2	171.1	

^a Average barometer for entire test, 29.74 inches. Test began at 8.50 a. m., but as the engine was taking an excessive amount of gas, it was shut down at 1.15 p. m. in order to change the ignition. The test began again at 1.30 p. m. December 21, on full load, which was carried until 9 a. m. December 22, when the load was reduced for two and one-half hours.

Log of producer-gas test No. 18, Texas No. 2 coal, December 21, 22, 1904—Continued.

Time.	(Coal consumed by producer (pounds).			Gas meter (cubic feet).			Temperature of gas (° F.).			Water meter (cubic feet).			Manometers at gas meter (inches water).			Auxiliary motors.			Speed counters on gas engine.			Load.			Temperature of gas leaving producer (° C.).			Manometers at producer.			Gas calorimeter.						B. T. U.	
1	2	3	4	5	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).			Manometers at producer.			Temperatures (° C.).						Cubic centimeters of water collected.			Cubic feet of gas.		As read.		Standardized.						
					1.	2.	Watt meter.		Ammeter.		1.	2.	Volts.	Ampers.	Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Outlet.	20	21	22																
2 p. m.	300	8,934,620	70.0			2.4	1.0				4,067	241	634																									
2.10 p. m.		8,930,400	70.0			2.4	1.0	839,910			6,082	240	634																									
2.30 p. m.	300																																					
2.45 p. m.		8,944,150	69.0			2.4	1.0				8,008	240	629																									
2.50 p. m.		8,948,900	69.0			2.4	1.1				10,115	239	629																									
3.10 p. m.		8,953,690	69.0			2.4	1.1	841,920			12,133	240	624																									
3.30 p. m.	300					2.4	1.1				14,152	240	614																									
3.50 p. m.		8,938,400	69.0			2.4	1.1				16,175	241	624																									
4.10 p. m.		8,963,360	69.0			2.4	1.2																															
4.15 p. m.	300																																					
4.30 p. m.		8,968,100	69.0			2.4	1.2	844,100			18,165	239	624																									
4.50 p. m.		8,973,180	68.5			2.4	1.2				20,222	241	624																									
5 p. m.	300																																					
5.10 p. m.		8,978,150	68.0			2.4	1.1				22,246	241	619																									
5.30 p. m.	300	8,983,000	68.0			2.4	1.2	846,100			24,271	240	624																									
5.50 p. m.		8,987,890	68.0			2.4	1.2				26,295	242	619																									
6 p. m.	300																																					
6.10 p. m.		8,992,770	68.0			2.5	1.2				28,319	242	624																									
6.30 p. m.		8,997,600	68.0			2.5	1.1	848,230			30,348	241	634																									
6.45 p. m.	300																																					
6.50 p. m.		9,002,490	67.5			2.5	1.1				32,378	242	624																									
7.10 p. m.		9,007,300	67.5			2.5	1.2				34,390	239	624																									
7.30 p. m.	300	9,012,150	67.5			2.5	1.2				36,407	240	624																									
7.50 p. m.		9,017,140	67.5			2.5	1.1	850,950			38,419	240	629																									
8.10 p. m.		9,022,290	67.0			2.5	1.1				40,431	242	624																									
8.15 p. m.	300																																					

Log of producer-gas test No. 18, Texas No. 2 coal, December 21, 22, 1904—Continued.

Time.	Coal consumed by producer (pounds).	(gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Temperatures (° C.).				Gas calorimeter.		B. T. U.	
				5	6	1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amps.		Air entering (inches mer- cury).	Gas leaving (inches wa- ter).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
8.30 p. m.		9,027,350	67.0			2.5				42,443	242	624	200			18.0	5.2	15.0	820	0.2	159.1	160.2		
8.50 p. m.		9,032,300	66.5			2.5	853,100			44,457	242	624				18.0	5.2	15.3	800	.2	160.3	161.5		
9 p. m.	300																							
9.10 p. m.		9,037,380	66.5			2.5				46,471	242	624				18.0	5.2	15.0	800	.2	150.6	151.6		
9.30 p. m.	300	9,042,400	66.5			2.5				48,492	240	624	240			18.0	5.2	15.1	800	.2	157.1	158.1		
9.50 p. m.		9,047,350	66.5			2.5	855,400			50,509	242	624		0.5	5.0	17.5	5.2	15.0	790	.2	153.6	154.5		
10.10 p. m.		9,052,400	66.5			2.5				52,524	242	614				17.5	5.2	14.8	800	.2	152.4	153.3		
10.15 p. m.	300																							
10.30 p. m.		9,057,900	66.0			2.5				54,542	242	624	250	.5	5.0	18.0	5.2	15.1	800	.2	157.1	158.1		
10.50 p. m.		9,062,850	66.5			2.4	857,600			56,860	241	619				18.0	5.2	14.6	800	.2	149.2	150.2		
11 p. m.	300																							
11.10 p. m.		9,068,160	66.5			2.4				58,569	241	624				17.5	5.2	14.4	840	.2	153.2	154.0		
11.30 p. m.		9,073,450	66.0			2.4				60,580	241	624	300			17.8	5.2	14.4	810	.2	150.0	150.8		
11.45 p. m.	300																							
11.50 p. m.		9,078,750	66.0			2.4	859,790			62,588	241	624				17.5	5.2	14.2	830	.2	148.0	148.7		
12.10 a. m. ^a		9,084,020	66.0			2.4				64,612	241	624				18.0	4.9	14.2	810	.2	149.6	150.6		
12.15 a. m.	300																							
12.30 a. m.		9,089,310	66.0			2.4	861,250			66,634	242	624	280	.4	4.0	17.8	5.2	14.8	820	.2	155.9	156.9		
12.50 a. m.		9,094,540	66.5			2.4				68,638	241	624				18.2	5.25	14.45	840	.2	153.2	154.5		
1 a. m.	300																							
1.10 a. m.		9,099,880	66.5			2.4				70,673	242	624				18.0	5.2	14.3	810	.2	146.0	147.0		
1.30 a. m.	300	9,105,180	66.5			2.4	863,600			72,683	240	624	320	.6	5.5	17.5	5.0	13.7	830	.2	143.2	144.1		
1.50 a. m.		9,110,620	66.5			2.4				74,711	241	624				17.5	5.1	13.8	840	.2	144.8	145.7		
2 a. m.	300																							

^a December 22.

PRODUCER-GAS TESTS.

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Log of producer-gas test No. 18, Texas No. 2 coal, December 21, 22, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Temperatures (° C.).				Gas calorimeter.		B. T. U.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
2.10 a. m.		9,115,940	66.5		2.4	1.0																				
2.30 a. m.		9,121,200	66.5		2.4	1.0	865,780			76,732	242	619		0.4	4.0	17.7	5.2	14.2	840	0.2	150.0			151.0		
2.45 a. m.	300									78,756	241	614				17.5	5.2	14.0	830		144.8			145.7		
2.50 a. m.		9,126,560	66.5		2.4	1.0				80,774	241	624				17.6	5.2	14.0	830		144.8			145.7		
3.10 a. m.		9,131,940	66.5		2.4	1.0				82,790	240	624				17.7	5.2	13.5	830		136.5			137.4		
3.15 a. m.	300																									
3.30 a. m.		9,137,420	66.5		2.4	1.0	867,930			84,800	241	624	380	4	4.5	18.0	5.2	13.6	840		140.0			141.0		
3.50 a. m.		9,143,130	66.5		2.2	.5				86,812	238	624				18.0	5.2	12.3	840		132.5			133.4		
4 a. m.	300																									
4.10 a. m.		9,149,500	66.5		2.2	.4				88,819	240	619				18.0	5.3	14.8	830		156.3			157.3		
4.30 a. m.	300	9,155,000	67.0		2.4	.8	870,150			90,834	240	619	340	.6	6.5	18.0	5.3	14.7	820		152.8			153.8		
4.50 a. m.		9,160,420	67.0		2.4	1.0				92,844	240	624				18.5	5.4	14.7	840		155.1			156.6		
5.10 a. m.		9,166,390	66.0		2.3	.7				94,846	240	624		.4	4.5	19.0	5.4	13.3	870		136.5			138.0		
5.15 a. m.	300																									
5.30 a. m.		9,172,420	67.0		2.3	.4	872,420			96,852	240	624	380			19.8	5.4	13.9	900		151.6			153.5		
5.50 a. m.	300	9,178,780	66.0		2.3	.3				98,859	240	629				19.0	5.5	14.3	900		139.9			141.5		
6.10 a. m.		9,185,300	66.0		2.3	.0				100,861	240	634				19.3	5.4	12.8	1,000		146.8			148.6		
6.30 a. m.	300	9,191,820	67.0		2.3	-.9	874,650			102,861	240	619	480			19.8	5.4	12.3	960		131.3			133.0		
6.50 a. m.		9,198,490	67.0		2.3	+.3				104,861	240	624				19.8	5.4	12.8	980		146.0			148.0		
7 a. m.	300																									
7.10 a. m.		9,204,900	67.0		2.3	.5				106,863	241	619				20.0	5.2	13.6	850		141.7			143.6		
7.30 a. m.		9,211,190	68.0		2.3	1.0	875,920			108,873	238	624	440			20.0	5.3	13.7	880		146.4			148.3		
7.45 a. m.	300																									
7.50 a. m.		9,217,440	68.0		2.3	.8				110,884	240	614				20.0	5.4	14.0	850		144.8			146.7		
8.10 a. m.		9,223,890	68.0		2.3	.6				112,897	238	624				20.8	5.5	12.8	940		137.3			138.3		

Log of producer-gas test No. 18, Texas No. 2 coal, December 21, 22, 1904—Continued.

Time.	(Coal consumed by producer) (pounds).	(Gas meter (cubic feet)).	Temperature of Gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).	Auxiliary motors.		Speed counters on gas engine.		Load.	Temperature of gas leaving producer (° C.).	Manometers at producer. (inches water). (Gas leaving meter).	Temperatures (° C.).			Gas calorimeter.			B. T. U.			
						Watt meter.	Ammeter.	1.	2.				Volts.	Amperes.	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.		Cubic feet of gas.	As read.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
8.15 a. m.	300																					
8.30 a. m.		9,230,340	70.0		2.3	0.4	879,080			114,903	240	624	460			21.1	5.6	13.7	1,000	0.2	160.7	162.0
8.45 a. m.	300																					
8.50 a. m.		9,237,150	70.0		2.3	.0				116,919	240	624										
9 a. m.																						
9.10 a. m.		9,243,910	72.0		2.2	-.2				118,935	238	574				23.0	5.6	12.4	1,150	.2	155.1	159.1
9.15 a. m.	300																					
9.30 a. m.		9,251,100	72.0		2.2	-.2				120,950	241	524	400			26.0	5.8	13.6	970	.2	150.0	155.2
9.45 a. m.	300																					
9.50 a. m.		9,258,300	73.0		2.0	-1.0	882,200			122,962	237	449				28.0	5.8	13.3	970	.2	146.0	152.1
10.10 a. m.		9,264,750	73.0		2.2	.0				124,982	239	474				29.0	6.1	14.2	1,000	.2	160.7	168.1
10.15 a. m.	300																					
10.30 a. m.		9,271,680	73.0		2.3	+.2				126,992	241	494	450	.8	6.5	26.1	5.8	13.1	1,080	.2	156.3	161.8
10.45 a. m.	300																					
10.50 a. m.		9,278,780	73.0		2.2	-.5	884,500			129,008	240	424				27.0	6.0	13.0	1,000	.2	138.9	144.3
11.10 a. m.		9,285,830	73.5		2.1	-.6				131,019	241	474				27.0	5.8	13.3	900	.2	134.1	139.4
11.15 a. m.	300																					
11.30 a. m.		9,293,100	75.0		2.1	.0				133,040	240	524	300	.8	6.5	26.0	5.7	14.8	880	.2	140.7	167.5
11.45 a. m.	300																					
11.50 a. m.		9,299,050	75.5		2.3	+.5	886,850			135,062	242	644				27.0	5.5	16.0	810	.2	168.6	175.3
12.10 p. m.		9,304,400	77.0		2.4	.9				137,087	241	619				28.0	5.5	16.3	800	.2	171.4	178.7
12.15 p. m.	300																					
12.30 p. m.		9,309,550	78.0		2.5	1.1	888,300			139,113	241	624	250			26.5	5.6	16.4	800	.2	171.4	177.8
12.45 p. m.	300																					
12.50 p. m.		9,314,680	79.0		2.4	.9				141,137	241	634		.5	4.0	28.0	5.6	16.6	800	.2	173.6	179.2

Log of producer-gas test No. 18, Texas No. 2 coal, December 21, 22, 1904—Continued.

Time.	Coal consumed by producer (pounds).		Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.	Temperature of gas leaving producer (° C.).	Manometers at producer.		Gas calorimeter.						B. T. U.		
	1.	2.				Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.			Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Temperatures (° C.).		Cubic centimeters of water collected.	Cubic feet of gas.	As read.			Standardized.
																	1.	2.						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
1.10 p. m.		9,319,880	79.5			2.4	1.0				143,170	240	634				28.0	5.6	16.2	840	0.2	176.6	182.3	
1.30 p. m.	300	9,325,600	78.5			2.3	.6	880,560			145,174	241	624	280			27.0	5.6	14.8	810	.2	148.0	153.6	
1.50 p. m.		9,331,050	78.0			2.4	1.0				147,198	240	614				26.0	5.6	15.6	820	.2	162.7	168.4	
2.10 p. m.		9,336,390	67.5			2.4	1.0				149,230	240	614		0.55	5.0	27.0	5.5	15.7	830	.2	167.9	174.3	
2.15 p. m.	300																							
2.30 p. m.		9,341,700	67.0			2.4	1.0	882,700			151,265	240	614	340			27.0	5.4	15.4	850	.2	168.6	175.0	

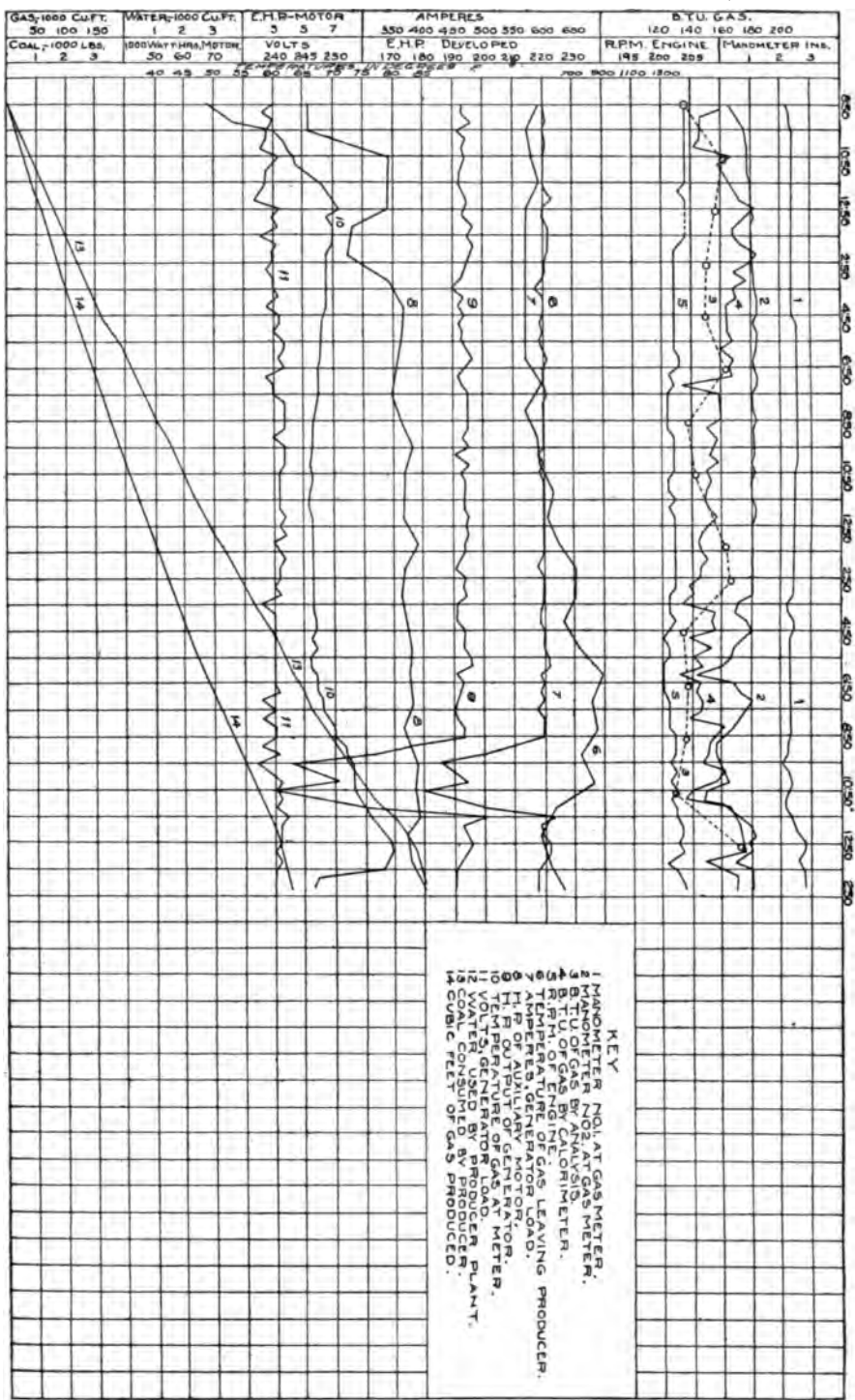


FIG. 126.—Graphic log sheet, Producer-gas test, Texas No. 2 coal.

OPERATIONS OF THE COAL-TESTING PLANT.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
8.52 a. m. ^a	9.0	0.6	17.0	10.4	2.9	60.1	100.0	136.4
11 a. m.	8.2	.0	18.4	8.6	6.2	58.6	100.0	160.2
1 p. m.	9.2	.6	21.0	9.2	4.0	56.0	100.0	156.0
3 p. m.	8.0	.4	21.6	5.9	5.0	59.1	100.0	150.2
5 p. m.	9.4	.2	21.6	10.0	3.6	55.2	100.0	148.5
7 p. m.	8.8	.0	21.0	11.0	4.9	54.3	100.0	162.8
9 p. m.	8.8	.2	20.0	7.9	3.9	59.2	100.0	136.6
11 p. m.	9.2	.6	19.2	5.7	5.1	60.2	100.0	141.2
1.45 a. m. ^b	10.0	.2	18.0	14.0	4.6	53.2	100.0	160.5
3 a. m.	10.2	.0	17.4	13.9	5.2	53.3	100.0	164.5
5 a. m.	11.0	.0	12.8	8.5	5.5	52.2	100.0	132.8
7 a. m.	11.0	.2	12.4	9.8	5.5	61.1	100.0	136.0
9 a. m.	11.6	.2	7.2	5.8	8.4	66.8	100.0	134.8
11 a. m.	12.4	.0	9.6	1.8	8.1	68.1	100.0	126.6
1 p. m.	10.8	.2	13.0	18.6	9.5	47.9	100.0	174.3

^a December 21.

^b December 22.

Producer-gas test No. 18, Texas No. 2 coal.

[Recorded by W. C. Weldmann, Kurt Toensfeldt, and R. E. Peshak, December 21, 22, 1904.]

1. Duration of test, in hours	19.33
AVERAGE TEMPERATURE, ° F.	
2. Gas leaving producer.....	559
3-6. (See footnote on p. 1027.)	
OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
7. Total steam used by producer.....pounds..	5,020
8. Steam used by producer per hour.....do....	260
9. Equivalent in pounds of coal per hour.....	51.5
10. Equivalent in pounds of dry coal per hour.....	34.1
11. Equivalent in pounds of combustible per hour.....	30.4
12. Average horsepower required to drive auxiliary machinery.....	11.6
COAL CONSUMED IN PRODUCER.	
16. Total coal consumed.....pounds..	9,050
17. Moisture in coal.....per cent..	33.71
18. Total dry coal consumed.....pounds..	5,999
19. Refuse from dry coal.....per cent..	10.98
20. Total refuse from coal.....pounds..	658.7
21. Total combustible consumed.....do....	5,340.3

PRODUCER-GAS TESTS.

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COAL PER HOUR.

22. Coal consumed in producer.....	pounds..	468
23. Dry coal consumed in producer.....	do.....	310.3
24. Combustible consumed in producer.....	do.....	276.2
25. Equivalent coal used by producer plant.....	do.....	519.5
26. Equivalent dry coal used by producer plant.....	do.....	344.4
27. Equivalent combustible used by producer plant.....	do.....	306.6

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired	pounds..	12.20
29. Dry coal.....	do.....	8.07
30. Combustible.....	do.....	7.18

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	7,348
32. Per pound of dry coal.....	11,086
33. Per pound of combustible.....	12,450
34. From coal as fired, per hour.....	3,440,000
35. From dry coal, per hour.....	3,440,000
36. From combustible, per hour.....	3,439,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.

37. Total.....	309,140
38. Per hour.....	16,009
39. Per pound coal consumed in producer.....	34.2
40. Per pound dry coal consumed in producer.....	51.6
41. Per pound combustible consumed in producer.....	57.9
42. Per pound equivalent coal used by producer plant.....	30.8
43. Per pound equivalent dry coal used by producer plant.....	46.4
44. Per pound equivalent combustible used by producer plant.....	52.2

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	156.2
46. Per pound dry coal burned in producer.....	8,060
47. Per hour per brake horsepower.....	10,570

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	189.6
49. Electrical horsepower developed at switch board.....	201.2
50. Brake horsepower available for outside purposes.....	233
51. Brake horsepower developed at engine.....	236.5

EFFICIENCIES.

52. Of conversion and cleaning gas.....	.727
53. Of producer plant.....	.650

OPERATIONS OF THE COAL-TESTING PLANT.

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	2. 47	1. 64	1. 46
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	2. 33	1. 54	1. 37
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	2. 10	1. 39	1. 24
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	1. 98	1. 31	1. 17
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	2. 74	1. 82	1. 62
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	2. 58	1. 71	1. 52
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	2. 33	1. 55	1. 38
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	2. 20	1. 46	1. 30

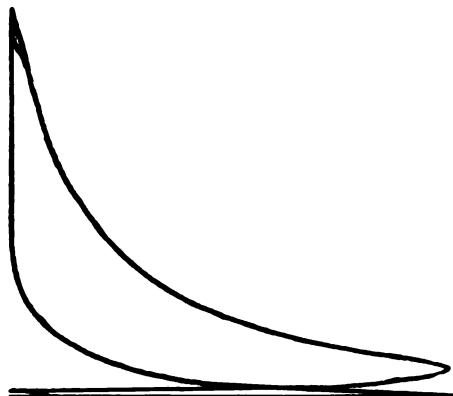
^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

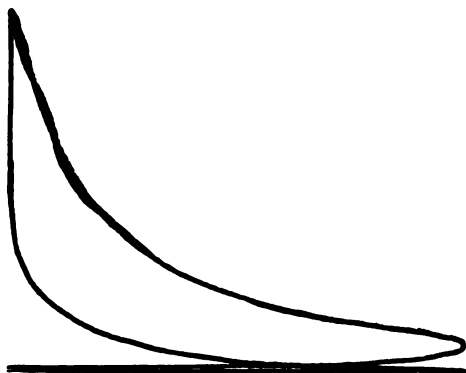
62. Coal:	Percent.	63. Gas by volume:	Percent.
Moisture.....	33. 71	Carbon dioxide (CO ₂).....	9. 60
Volatile matter.....	29. 25	Oxygen (O ₂).....	. 20
Fixed carbon.....	29. 76	Carbon monoxide (CO).....	18. 22
Ash.....	7. 28	Hydrogen (H ₂).....	9. 63
	100. 00	Methane (CH ₄).....	4. 81
Sulphur.....	. 53	Nitrogen (N ₂).....	57. 54
			100. 00

Test No. 18 began at 8.50 a. m. December 21, but the ignition setting of the engine was found to be faulty. The engine was shut down at 1.15 p. m. in order to make the necessary change in this ignition setting. The portion of the test covered by the report began at 1.30 p. m. December 21 and continued to 8.30 a. m. December 22 (19.33 hours), after which time the load carried by the engine was very irregular.

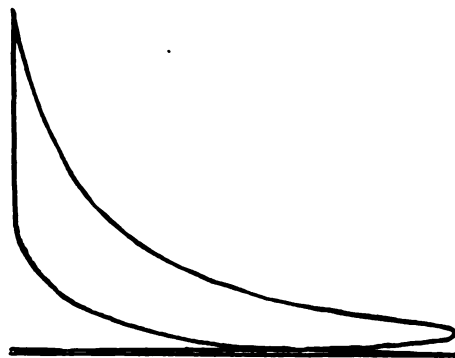
From the standpoint of the producer operator "Texas No. 2 is a brown lignite that gave highly satisfactory results in the producer, yielding a rich gas. It is an excellent fuel for producers."



Right cylinder. M. E. P., 57; Max., 320; Rel., 30; I. H. P., 91.4.



Center cylinder. M. E. P., 58; Max., 300; Rel., 28; I. H. P., 93.



Left cylinder. M. E. P., 58; Max., 290; Rel., 28; I. H. P., 83.4.

Indicator diagrams taken December 21, 1904, during gas-engine test No. 18, on Texas No. 2 coal. Revolutions per minute, 203.6.

From the standpoint of the engine operator "this would have been a good test if the time of the spark could have been shifted to meet the changes in the gas. The indicator cards from this run show these changes very distinctly."

Sixty gallons of yellow tar resulted from this run.

GAS ENGINE.

Following are results of tests by gas engine:

Report of gas-engine test No. 18.

Recorded by K. Toensfeldt and W. C. Weidmann, December 21, 22, 1904.

Producer test No. 18.

Coal: General number, Texas No. 2; special number, G. P. 18. Car initials and number, St. L., I. M. and S. 12579.

Duration of test, in hours.....	19½
Revolutions per minute (mean).....	201.6
Explosions per minute (mean).....	100.8
Cubic feet gas per hour, by meter.....	16,190
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	15,990
Maximum pressure:	
First cylinder.....	241
Second cylinder.....	271
Third cylinder.....	255
Pressure at release:	
First cylinder.....	31
Second cylinder.....	28.3
Third cylinder.....	26
Mean effective pressure:	
First cylinder.....	61
Second cylinder.....	58.2
Third cylinder.....	52.8
Indicated horsepower:	
First cylinder.....	96.7
Second cylinder.....	92.46
Third cylinder.....	83.75
Total indicated horsepower.....	272.91
Horsepower delivered (electrical horsepower).....	201.2
Mechanical efficiency (engine and generator combined)..... per cent..	73.7
Cubic feet standard gas per hour per indicated horsepower.....	58.6
Cubic feet standard gas per hour per electrical horsepower.....	79.5

WEST VIRGINIA No. 1.

GENERAL RESULTS.

The general results of tests of West Virginia No. 1 coal are tabulated as follows:

Log of producer-gas test No. 3, West Virginia No. 1 coal, October 17, 18, 1904.
[Coal from mine of the Virginia and Pittsburgh Coal Company, Kingmont, W. Va.]

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).	Auxiliary motors.					Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Gas calorimeter.				B. T. U.									
						Watt meter.		Ammeter.			1.		2.			Volts.	Amperes.	Air entering (inches mercury).	Gas leaving (inches water).	Temperatures (° C.).		Cubic centimeters of water collected.	Cubic feet of gas.		As read.	Standardized.					
						1.	2.	8	9	10	11	12	13	14						15	16		17	18			19	20	21	22	23
12.30 p. m. ^a		1,888,710	72.5	36,310	2.1	0.2				12,322		241	624	470	0.7	6.5															
12.50 p. m.		1,895,760	73.0		2.1	.3				14,321		243	619	510	.7	6.5															
1 p. m.																															
1.10 p. m.		1,902,780	73.0		2.1	.1				16,320	56,320	241	629	495	.7	7.5															
1.15 p. m.	300																														
1.20 p. m.																															
1.30 p. m.	300	1,910,250	73.5		1.9	.1				18,294	58,294	243	619	520	9	7.5			28.0	19.50	27.01	1,300	.3	126.1	135.9						
1.40 p. m.																															
1.50 p. m.		1,917,670	74.0		2.1	.2				20,285	60,285	242	619	480	.8	7.5			28.0	19.50	26.45	1,920	.4	132.4	139.4						
2 p. m.																															
2.10 p. m. ^b		1,925,025	73.5		2.0	.7				22,225	62,225	241	537	610	.8	3.0			27.8	19.50	26.20	1,980	.4	131.7	138.9						
2.20 p. m.	300																														
2.30 p. m.		1,933,200	74.0	36,700	1.5	1.9				24,065	64,065	251	532	480	.8	8.5			28.0	19.50	23.84	1,800	.3	92.0	97.0						
2.40 p. m.																															
2.50 p. m.	300	1,941,220	74.5		2.1	.1				26,120	66,120	223	522	500	.6	8.0			27.8	19.60	24.20	1,270	.2	115.9	122.3						
3 p. m.																															
3.10 p. m. ^c		1,948,500	75.0		2.0	.2				28,139	68,139	240	619	510	.8	8.5			27.0	19.40	23.96	1,420	.2	1.284	134.6						
3.20 p. m.																															
3.30 p. m.		1,955,880	75.0		2.1	.0				30,167	70,167	241	619	480	.8	6.5			28.0	19.40	23.80	1,440	.2	125.7	131.5						
3.40 p. m.																															
3.50 p. m.		1,963,250	75.0		2.0	.1				32,162	72,162	241	619	480	.8	7.5			28.0	19.35	23.60	1,500	.2	134.0	141.9						
4 p. m.																															
4.10 p. m.		1,970,450	75.0		2.0	.0				34,162	74,162	239	619	530	.8	7.0			26.0	19.35	23.60	1,500	.2	134.0	141.9						

^a October 17. 12.30 p. m. to 6.10 p. m. barometer 29.59 inches; 6.10 p. m. to 7 a. m. October 18. barometer 29.57 inches.
^b Engine missed explosions frequently and load had to be reduced.
^c Full load resumed.

Log of producer-gas test No. 3, West Virginia No. 1 coal, October 17, 18, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Gas calorimeter.				B. T. U.	
		Gas meter (cubic feet).	Gas meter (cubic feet).	1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	Temperature of gas leaving producer (° C.).	Air entering (inches mercury).	Gas leaving (inches water).	Ter.	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.		Standardized.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
4.20 p. m.		1,977,900	75.0	37,105	2.0	0.4			36,140	76,140	241	619	400	0.8	7.0								
4.30 p. m.		1,985,400	74.5		2.0	0.2			38,140	78,140	239	629	430	0.8	7.0								
4.50 p. m.																							
5 p. m.	300																						
5.05 p. m.		1,992,800	74.0		2.0	0.6			40,135	80,135	243	619	390	.8	7.0								
5.10 p. m.		1,999,350	73.0		2.3	.8			42,149	82,149	244	619	535	.5	5.0	23.0	19.20	23.00	1,770	.2	133.4	138.3	
5.30 p. m.		2,005,950	72.5		2.3	.6			44,165	84,165	243	619	430	6	5.0	24.5	19.18	21.80	2,550	.2	151.5	157.0	
5.50 p. m. ^a	300	2,012,450	72.0		2.2	.4			46,162	86,162	242	629	510	6	5.0								
6.10 p. m.																							
6.25 p. m.		2,019,200	71.5	37,544	2.3	.8			48,172	88,172	242	624	400	5	4.5								
6.30 p. m.	300	2,025,000	71.5		2.5	1.1			50,186	90,186	242	619	400	5	6.4								
6.50 p. m.		2,030,710	71.5		2.5	1.1			52,190	92,190	239	619	465	5	6.4								
7.10 p. m.																							
7.20 p. m. ^b		2,036,900	70.0		2.4	1.0			54,153	94,153	242	619	380	.5	5.2								
7.30 p. m.	300	2,042,980	69.5		2.4	.9			56,165	96,165	242	619	425	.6	5.6								
7.45 p. m.																							
7.50 p. m.		2,049,160	69.0		2.4	.9			58,176	98,176	243	619	390	.5	4.7								
8.05 p. m.																							
8.10 p. m.		2,055,250	68.5	37,976	2.4	.9			60,190	100	243	619	405	.6	5.8								
8.25 p. m.	300	2,061,320	68.0		2.4	.9			38.0		243	619	435	.5	5.6								
8.30 p. m.									31.0	62,204	2,204	241	619	435	.5	5.6							
8.45 p. m.																							
8.50 p. m.		2,067,460	68.0		2.4	.9			32.0	64,216	4,216	241	619	400	.5	5.3							
9.05 p. m.																							
9.10 p. m.																							

^a At 5.58 p. m. the circuit breaker blew out, owing to the carelessness of an attendant.^b At 7.23 p. m. one of the engine igniters worked badly, and the speed of the engine fell off temporarily.

Log of producer-gas test No. 3, West Virginia No. 1 coal, October 17, 18, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Gas calorimeter.				B. T. U.			
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercury).	Gas leaving (inches water).	Temperatures (° C.).		Cubic centimeters of water collected.	Cubic feet of gas.				
																Gas.	Inlet.				Outlet.	Water.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
9.25 p. m.	300	2,073,570	67.0		2.4	0.9		40.0	66,230	6,230	241	619	420	0.5	5.3	19.5	19.00	28.60	1,730	0.5	131.7		138.9
9.30 p. m.																							
9.45 p. m.		2,079,560	67.0		2.4	1.0		34.0	68,243	8,243	243	614	420	.6	5.5	20.0	19.00	28.55	1,790	.5	135.6		139.1
9.50 p. m.																							
10.05 p. m.		2,085,480	66.5		2.4	1.0		38.0	70,256	10,256	241	619	420	.5	5.2	19.5	19.00	28.67	2,160	.6	138.1		141.5
10.10 p. m.	300																						
10.25 p. m.		2,091,520	66.5	38,380	2.4	.9		43.0	72,265	12,265	242	624	360	5	6.4	19.3	19.00	28.34	1,800	.5	133.3		136.4
10.30 p. m.																							
10.45 p. m.		2,097,450	66.5		2.4	1.0		35.0	74,277	14,277	242	619	450	6	6.2	19.0	19.00	28.65	1,770	.5	127.6		130.5
11.05 p. m.	300	2,103,510	66.0		2.4	.9		37.0	76,286	16,286	241	614	450	5	5.4	19.0	19.05	28.40	1,900	.5	140.9		144.0
11.10 p. m.																							
11.25 p. m.																18.	19.20	28.22	2,250	.6	134.1		138.8
11.30 p. m.		2,109,720	66.0		2.4	.9		42.0	78,292	18,292	243	619	420	4	4.7								
11.50 p. m.		2,115,780	66.0		2.4	.8		38.0	80,299	20,299	242	614	420	5	4.9								
12 p. m.																20.0	19.10	27.90	4,000	1.0	138.4		143.0
12.10 a. m. a.	300	2,121,940	66.5		2.4	.8		31.0	82,308	22,308	241	619	445	5	5.3	19.	19.20	28.08	2,700	.7	125.7		129.0
12.25 a. m.																							
12.30 a. m.		2,128,120	66.5	38,780	2.4	.9		42.0	84,315	24,315	242	624	370	6	6.0								
12.50 a. m.		2,134,175	66.0		2.3	.8		34.5	86,329	26,329	241	619	430	6	4.5	20.0	19.40	27.30	2,000	.5	149.2		158.0
1.10 a. m.		2,140,450	66.0		2.4	.9		34.0	88,323	28,323	241	619	445	4	5.5	20.2	19.40	27.01	2,500	.6	125.8		129.2
1.15 a. m.	300																						
1.30 a. m.		2,146,760	66.0		2.3	.9		34.5	90,324	30,324	242	614	410	.5	6.0								
1.35 a. m.																20.2	19.30	27.27	2,500	.6	121.7		124.8
1.50 a. m.		2,152,860	66.0		2.3	.9		34.5	92,338	32,338	242	614	410	.6	6.0								

October 18. Barometer 29.52 inches.

PRODUCER-GAS TESTS.

Log of producer-gas test No. 3, West Virginia No. 1 coal, October 17, 18, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Gas calorimeter.				B. T. U.	
				1.	2.	1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amps.	Gas.	Water.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.		
1	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1.55 a. m.																							
2.10 a. m.		2,159,100	66.0		2.4	0.9			31.0	94,343	34,343	243	614	400	0.6	5.5							
2.15 a. m.	300																						
2.30 a. m.		2,165,450	66.0	39,200	2.2	.6			40.0	96,345	36,345	239	619	490	.6	5.5							
2.45 a. m.																							
2.50 a. m.		2,172,190	66.0		2.3	.8			42.0	98,352	38,352	242	624	420	.6	5.5							
3.05 a. m.																							
3.10 a. m.		2,178,640	66.0		2.3	.8			33.5	367	40,367	242	614	350	.5	5.0							
3.15 a. m.	300																						
3.25 a. m.																							
3.30 a. m.		2,185,130	66.0		2.3	.8			37.5	2,382	42,382	242	619	400	.5	6.0							
3.45 a. m.																							
3.50 a. m.		2,191,590	66.0		2.3	.8			32.5	4,396	44,396	242	609	420	.5	5.5							
4.05 a. m.	300																						
4.10 a. m.		2,196,150	66.0		2.3	.8			33.0	6,410	46,410	241	624	440	.7	6.0							
4.25 a. m.																							
4.30 a. m.		2,204,790	65.5	39,537	2.3	.8			35.0	8,418	48,418	241	624	350	.7	6.25							
4.45 a. m.																							
4.50 a. m.		2,211,000	66.0		2.3	1.0			30.0	10,430	50,430	241	614	450	.7	6.5							
5 a. m.	300																						
5.05 a. m.																							
5.10 a. m.		2,217,290	66.0		2.4	.9			35.0	12,441	52,441	241	619	370	.7	6.5							
5.25 a. m.																							
5.30 a. m.		2,223,580	65.0		2.4	.9			29.5	14,450	54,450	243	624	470	.6	6.25							
5.45 a. m.																							
5.50 a. m.		2,230,680	66.0		2.5	1.1			30.0	16,463	56,463	241	614	420	.5	4.5							

PRODUCER-GAS TESTS.

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Log of producer-gas test No. 3, West Virginia No. 1 coal, October 17, 18, 1904—Continued.²

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving (° C.).	Manometer at pro- ducer.		Temperatures (° C.).		Gas calorimeter.					
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mer- cury).	Gas leaving (inches wa- ter).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	B. T. U.		
																					As read.	Standardized.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
6.05 a. m.	300	2,235,620	65.5		2.4	1.1		28.0	18,473	58,473	242	619	430	0.5	6.5		20.1	19.20	26.50	1,500	0.3	134.8	138.0
6.10 a. m.																							
6.25 a. m.		2,241,450	66.0	39,832	2.5	1.2		34.0	20,487	60,487	228	619	410	.5	4.0		21.0	19.20	26.90	1,800	.4	137.3	141.3
6.30 a. m.																							
6.45 a. m.		2,246,910	66.0		2.4	1.3		32.0	22,511	62,511	241	619	380	.5	4.5		21.0	19.20	27.50	1,800	.4	148.4	152.6
7.05 a. m.		2,252,350	66.5		2.4	1.2		33.0	24,524	64,524	241	619	380	.6	5.5		21.0	19.20	27.10	1,850	.4	144.8	149.0
7.10 a. m.	300																						
7.15 a. m.		2,238,000	67.0		2.4	1.2		32.0	20,536	66,536	240	619	375	.1	1.0								
7.30 a. m.		2,264,000	68.0		2.3	1.0		28.0	28,540	68,540	242	619	400	.5	5.5								
7.50 a. m.	300	2,270,000	71.0		2.3	1.0		30.0	30,555	70,555	243	619	370	.5	5.0								
8.00 a. m.		2,275,920	72.5	40,064	2.3	1.0		31.0	32,570	72,570	242	619	375	.4	4.2	30.3	19.60	27.90	1,850	.4	152.4	161.9	
8.30 a. m.		2,281,860	73.5		2.3	1.0		30.0	34,588	74,588	242	619	380	.2	2.0	28.0	19.80	28.00	1,900	.4	154.4	162.7	
8.50 a. m.		2,287,740	74.0		2.3	1.0		34.0	36,607	76,607	242	609	400	.5	5.2	28.0	19.40	27.40	1,850	.4	146.9	155.4	
9.10 a. m.		2,293,750	75.0		2.3	1.0		32.0	38,622	78,622	240	629	380	.2	3.0	30.0	19.42	27.30	1,900	.4	146.8	155.8	
9.30 a. m.	300	2,299,880	77.0		2.3	1.0		31.0	40,639	80,639	241	619	375	.5	5.0	32.0	19.60	27.00	1,800	.4	130.6	139.7	
9.50 a. m.		2,305,000	78.0		2.3	1.0		32.0	42,650	82,650	241	619	430	.2	3.0	33.0	19.00	27.70	1,800	.4	148.8	156.6	
10.10 a. m.		2,312,210	79.0	40,378	2.3	.8		32.0	44,663	84,663	241	619	430	.5	4.5	33.0	19.65	27.30	1,850	.4	139.7	150.0	
10.30 a. m.	300	2,318,470	79.0		2.3	1.0		32.0	46,678	86,678	240	609	410	.5	4.5	34.0	19.70	27.70	2,250	.5	142.8	153.5	
10.50 a. m.		2,324,620	80.0		2.3	1.0		28.0	48,692	88,692	241	614	425	.6	5.5	34.0	19.70	27.60	1,800	.4	140.9	151.5	
11.10 a. m.		2,330,790	80.0		2.3	.9		30.0	50,710	90,710	241	614	380	.5	4.5	35.0	19.90	27.70	2,300	.5	144.0	155.4	
11.50 a. m.	300	2,337,080	80.0		2.3	.8		31.0	52,723	92,723	242	619	400	.4	4.5	35.0	19.80	27.00	1,300	.3	134.0	144.6	
12.10 p. m.		2,343,400	80.0		2.3	.7		31.5	54,731	94,731	241	619	400	.5	4.5								
12.30 p. m.		2,349,780	80.0	40,565	2.3	.9		28.0	56,740	96,740	241	619	410	.5	4.0	34.0	19.70	27.80	1,800	.4	144.8	155.7	
12.55 p. m.	300																						

OPERATIONS OF THE COAL-TESTING PLANT.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
12.40 p. m. ^a	9.8	0.0	16.7	4.2	2.8	66.5	100.0	102.7
2.20 p. m.	12.2	.4	11.4	6.3	1.2	68.5	100.0	74.5
4.20 p. m.	11.8	.2	14.0	1.1	2.8	70.1	100.0	82.5
6.20 p. m. ^c	11.0	.2	14.4	7.0	5.8	61.6	100.0	136.3
8.20 p. m.	9.8	.2	16.8	3.4	4.0	65.8	100.0	113.1
10.20 p. m.	10.4	.2	15.4	1.8	3.6	68.6	100.0	98.4
12.20 a. m. ^b	11.2	.3	14.1	2.3	4.0	68.1	100.0	99.8
2.10 a. m.	12.0	.0	13.6	3.2	4.7	66.5	100.0	108.7
4.10 a. m.	11.8	.0	14.0	7.1	2.9	64.2	100.0	104.5
6.10 a. m.	11.2	.2	14.2	7.7	2.4	64.3	100.0	101.9
8.10 a. m.	8.0	.2	14.2	.0	5.6	72.0	100.0	109.2
10.10 a. m.	10.0	.0	15.0	2.7	6.0	66.3	100.0	125.6
12.10 p. m.	10.2	.0	13.8	.0	6.0	70.0	100.0	112.1
2.10 p. m. ^c	10.4	.2	14.5	.0	13.3	61.6	100.0	192.2
4.10 p. m.	10.6	.1	15.3	15.7	4.7	53.6	100.0	158.1

^a October 17.

^b October 18.

^c Gas analysis thrown out.

Producer-gas test No. 3, West Virginia No. 1 coal.

[Recorded by M. H. Mount and R. E. Peshak, October 17, 18, 1904.]

1. Duration of test, in hours.....	24
AVERAGE TEMPERATURE, ° F.	
2. Gas leaving producer.....	768
3-6. (See footnote on p. 1027.)	
OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
7. Total steam used by producer.....pounds..	5,900
8. Steam used by producer per hour.....do.....	246
9. Equivalent in pounds of coal per hour.....	33.1
10. Equivalent in pounds of dry coal per hour.....	32.6
11. Equivalent in pounds of combustible per hour.....	30.6
12. Average horsepower required to drive auxiliary machinery.....	10.3
13. Total water used in scrubber and tar extractor.....cubic feet..	3,623
14. Cubic feet of water per hour per horsepower of producer plant.....	.605
15. Cubic feet of water per 1,000 cubic feet of gas produced.....	8.3
COAL CONSUMED IN PRODUCER.	
16. Total coal consumed.....pounds..	6,900
17. Moisture in coal.....per cent..	1.61
18. Total dry coal consumed.....pounds..	6,790
19. Refuse from dry coal.....per cent..	6.24
20. Total refuse from coal.....pounds..	423.5
21. Total combustible consumed.....do....	6,366.5

PRODUCER-GAS TESTS.

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COAL PER HOUR.

22. Coal consumed in producer.....	pounds..	287.5
23. Dry coal consumed in producer.....	do.....	283
24. Combustible consumed in producer.....	do.....	265.5
25. Equivalent coal used by producer plant.....	do.....	320.6
26. Equivalent dry coal used by producer plant.....	do.....	315.6
27. Equivalent combustible used by producer plant.....	do.....	296.1

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired.....	pounds..	7.47
29. Dry coal.....	do.....	7.36
30. Combustible.....	do.....	6.91

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	14,166
32. Per pound of dry coal.....	14,396
33. Per pound of combustible.....	15,350
34. From coal as fired, per hour.....	4,075,000
35. From dry coal, per hour.....	4,075,000
36. From combustible, per hour.....	4,075,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	435,500
38. Per hour.....	18,150
39. Per pound coal consumed in producer.....	63.2
40. Per pound dry coal consumed in producer.....	64.1
41. Per pound combustible consumed in producer.....	68.4
42. Per pound equivalent coal used by producer plant.....	56.6
43. Per pound equivalent dry coal used by producer plant.....	57.5
44. Per pound equivalent combustible used by producer plant.....	61.3

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	144.4
46. Per pound dry coal burned in producer.....	9,260
47. Per hour per brake horsepower.....	11,130

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	190.1
49. Electrical horsepower developed at switch board.....	200.4
50. Brake horsepower available for outside purposes.....	223.8
51. Brake horsepower developed at engine.....	235.5

EFFICIENCIES.

52. Of conversion and cleaning gas.....	.643
53. Of producer plant.....	.574

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	1. 51	1. 49	1. 40
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	1. 43	1. 11	1. 33
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	1. 29	1. 27	1 19
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	1. 22	1. 20	1. 13
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	1. 69	1. 66	1. 56
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	1. 60	1. 57	1. 48
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	1. 43	1. 41	1. 33
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	1. 36	1. 34	1. 26

^a Based on an assumed efficiency of 85 per cent for generator and belt.

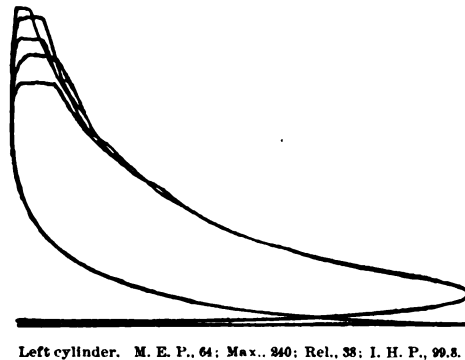
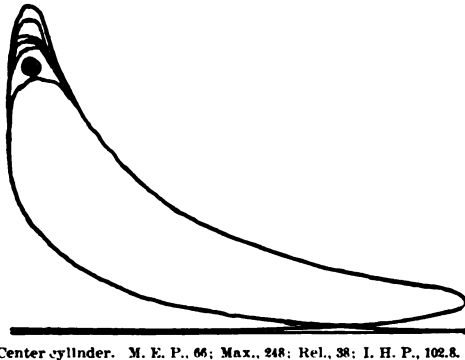
AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	1. 61	Carbon dioxide (CO ₂).....	10. 50
Volatile matter.....	36. 85	Oxygen (O ₂).....	. 10
Fixed carbon.....	55. 40	Carbon monoxide (CO).....	14. 34
Ash.....	6. 14	Hydrogen (H ₂).....	2. 81
	100. 00	Methane (CH ₄).....	5. 56
		Nitrogen (N ₂).....	66. 69
Sulphur.....	. 87		100. 00

During the early part of this test some difficulty was encountered in the manipulation of the producer. The gas production and the corresponding load carried by the engine varied so greatly that the first six hours of the test were regarded as "preliminary" only and were thrown out in the calculations of the report. The report is, therefore, calculated on the basis of a 24-hour run, from 6.30 p. m. October 17 to 6.30 p. m. October 18.

The report of the gas-producer operator is as follows:

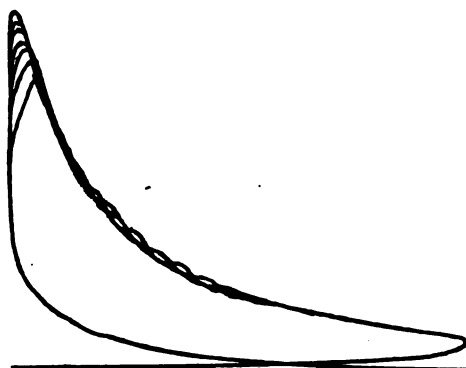
Previous to starting the test on this coal the tar extractor was removed and a new one substituted. As it was necessary to take the producer operator



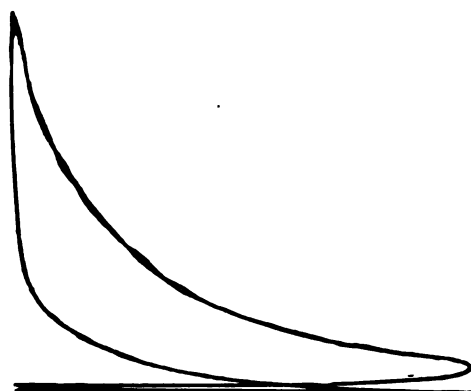
Indicator diagrams taken October 17, 1904, during gas-engine test No. 3, on West Virginia No. 1 coal. Scale of spring, 80; revolutions per minute, 197.4.

from his work to assist in placing the new extractor, the producer did not receive any attention for a few days and was in bad condition when the test was started. It was thought best to see if the producer could be made to carry full load and build up its bed into good running condition at the same time. The load was carried and the producer was in good shape for the official test six hours after being put into operation.

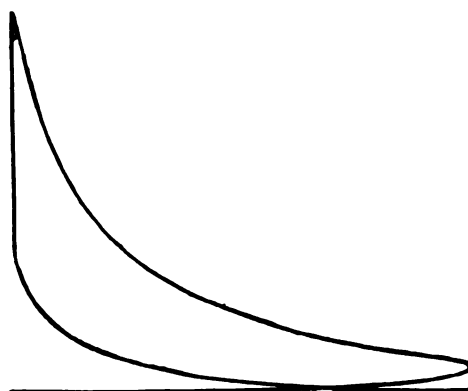
Two sets of indicator cards are shown. The first set was taken during the early part of the test and the second set was taken during the latter part. The ignition setting was the same throughout the test. The cards show clearly the difference in the rate of flame propagation due to variations in the gas compo-



Right cylinder. M. E. P., 60; Max., 274; Rel., 30; I. H. P., 96.



Center cylinder. M. E. P., 57; Max., 298; Rel., 30; I. H. P., 90.2.



Left cylinder. M. E. P., 61; Max., 298; Rel., 30; I. H. P., 96.6.

Indicator diagrams taken October 18, 1904, during gas-engine test No. 3, on West Virginia No. 1 coal. Scale of spring, 80; revolutions per minute, 201.1.

sition. These variations in gas composition were produced by the different thicknesses of fuel bed carried during the test and consequent fluctuations in the temperatures within the producer.

PRODUCER-GAS TESTS.

1239

GAS ENGINE.

Following are results of tests by gas engine:

Report of gas-engine test No. 3.

Recorded by R. W. Cummings and W. C. Weidmann, October 17, 18, 1904.

Producer test No. 3.

Coal: General number, West Virginia No. 1; special number, G. P. 3. Car initials and number, B. and O. 67796.

Duration of test, in hours.....	24
Revolutions per minute (mean).....	200.9
Explosions per minute (mean).....	100
Cubic feet gas per hour, by meter.....	18,680
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	18,140
Maximum pressure:	
First cylinder.....	242
Second cylinder.....	244.8
Third cylinder.....	240.8
Pressure at release:	
First cylinder.....	30.9
Second cylinder.....	31.2
Third cylinder.....	30
Mean effective pressure:	
First cylinder.....	61.06
Second cylinder.....	59.8
Third cylinder.....	56.6
Indicated horsepower:	
First cylinder.....	96.68
Second cylinder.....	94.68
Third cylinder.....	89.72
Total indicated horsepower.....	281.08
Horsepower delivered (electrical horsepower).....	200.4
Mechanical efficiency (engine and generator combined).....per cent..	71.1
Cubic feet standard gas per hour per indicated horsepower.....	64.5
Cubic feet standard gas per hour per electrical horsepower.....	90.7

WEST VIRGINIA No. 4.

GENERAL RESULTS.

The general results of tests of West Virginia No. 4 coal are shown in the following tables:

Log of producer-gas test No. 4, West Virginia No. 4 coal, October 20, 1904.

[Coal from mine of the West Virginia Coal Company, Bretz, W. Va.]

Time.	Coal consumed by producer (pounds).		Gas meter (cubic feet).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.				Speed counters on gas engine.		Load.		Temperature of gas leaving producer (°C.).		Manometers at producer.		Gas calorimeter.				B. T. U.	
																					Temperatures (°C.).					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23			
8.30 a. m. a		2,472,950	55.0	44,064	2.3	0.6		31.5	95,014	35,014	241	614	365	0.5	5.75											
8.50 a. m.		2,479,620	66.5		2.3	.4		34.5	97,018	37,018	242	629	430	.55	5.5											
9 a. m.	300																									
9.10 a. m.		2,486,400	68.0		2.3	.5		33.5	99,023	39,023	241	619	445	.7	5.5											
9.25 a. m.																										
9.30 a. m.		2,463,150	68.0		2.3	.5		32.5	1,030	41,030	241	619	440	.6	5.5											
9.45 a. m.																										
9.50 a. m.		2,469,650	68.5		2.3	.3		29.5	3,032	43,032	241	619	440	.6	5.5											
10 a. m.																										
10.10 a. m.		2,507,000	69.0		2.3	.3	8,150	32.5	5,034	45,034	241	619	460	.6	5.5											
10.15 a. m.	300																									
10.20 a. m.																										
10.30 a. m.		2,513,850	70.0	44,225	2.3	.7		32.5	7,037	47,037	241	619	400	.5	5.0											
10.45 a. m.																										
10.50 a. m.		2,520,150	71.5		2.3	.9		32.5	9,047	49,047	241	619	420	.5	5.0											
11.05 a. m.																										
11.10 a. m.		2,526,350	72.0		2.3	.8	10,210	28.5	11,056	51,056	239	614	400	.55	4.75											
11.25 a. m.																										
11.30 a. m.		2,532,000	72.5		2.3	.8		26.5	13,065	53,065	237	609	450	.5	5.0											
11.45 a. m.	300																									
11.50 a. m.		2,539,100	72.0		2.3	.7		28.5	15,070	55,070	242	619	430	.45	4.75											
12.05 p. m.																										
12.10 p. m.		2,545,450	72.5		2.3	.7	12,050	28.5	17,077	57,077	241	619	420	.55	5.5											
12.25 p. m.																										

a October 20. Barometer 29.28 inches.

PRODUCER-GAS TESTS.

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Log of producer-gas test No. 4, West Virginia No. 4 coal, October 20, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometer at producer.		Gas calorimeter.						
				Water meter (cubic feet).		Watt meter.	Ammeter.	1. 2.		Volts.	Amperes.	Air entering (inches mercury).	Gas leaving (inches water).	Temperatures (° C.).			Cubic centimeters of water collected.	Cubic feet of gas.	B. T. U.			
				1.	2.			Inlet.	Outlet.					As read.	Standardized.							
																1.			2.	Gas.	Water.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
12.30 p. m.		2,551,780	72.0	44,385	2.3	0.7		26.5	19,083	59,083	241	619	455	0.45	4.0							
12.50 p. m.		2,538,150	72.0		2.3	.8		27.5	21,087	61,087	240	614	440	.5	5.0							
1 p. m.	300																					
1.10 p. m.		2,564,580	72.0		2.3	.7	13,900	28.5	23,083	63,083	240	619	440	.5	4.7							
1.25 p. m.																						
1.30 p. m.		2,570,970	72.0		2.3	.7		28.5	25,105	65,105	242	619	440	.5	5.0	21.0	18.50	27.30	1,680	0.4	147.2	162.5
1.45 p. m.		2,577,440	72.0													23.0	18.50	26.92	1,800	.4	150.0	156.7
1.50 p. m.					2.3	.7		28.5	27,115	67,115	242	619	420	.5	5.3	23.0	18.40	26.51	1,670	.4	134.1	139.3
2.05 p. m.	300	2,583,930	71.0		2.3	.7	15,760	27.5	29,123	69,123	242	614	425	.5	5.2	21.0	18.40	26.80	1,700	.4	143.2	148.4
2.10 p. m.																						
2.25 p. m.		2,580,200	70.0	44,531	2.3	1.0		27.5	31,131	71,131	240	624	415	.5	4.8	21.7	18.30	26.83	1,680	.4	142.8	148.0
2.30 p. m.					2.4	1.0		12.5	33,140	73,140	241	619	420	.5	5.0	21.5	18.30	26.26	1,360	.3	143.2	148.6
2.45 p. m.		2,596,310	69.0																			
2.50 p. m.					2.4	.9	17,560	21.5	35,146	75,146	240	624	420	.5	5.0							
3.05 p. m.		2,602,500	68.5																			
3.10 p. m.	300																					
3.15 p. m.																						
3.25 p. m.		2,608,810	70.0		2.3	.8		26.5	37,148	77,148	243	624	400	.55	5.0	18.7	18.30	26.36	1,750	.4	139.7	147.6
3.30 p. m.																						
3.45 p. m.		2,615,200	68.0		2.3	.9		26.5	39,156	79,156	241	614	400	.5	5.0	19.3	18.30	26.59	1,720	.4	142.6	146.7
3.50 p. m.																						
4.05 p. m.		2,615,200	68.0		2.3	.9		26.5	39,156	79,156	241	614	400	.5	5.0	20.8	18.20	26.40	1,680	.4	139.3	144.4
4.10 p. m.		2,621,400	69.0		2.3	.9	19,090	26.5	41,165	81,165	243	619	400	.5	5.0	20.7	18.20	26.76	1,340	.3	133.7	138.5
4.25 p. m.																						
4.30 p. m.		2,627,710	70.0	44,697	2.3	.8		26.5	43,173	83,173	241	614	410	.5	5.0							
4.40 p. m.	300																					
4.45 p. m.																						

Log of producer-gas test No. 4, West Virginia No. 4 coal, October 20, 1904—Continued.

Time.	Coal consumed by producer (pounds).	1	Manome- ters at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Manome- ters at pro- ducer.		Gas calorimeter.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
			Water meter (cubic feet).		Temperature of gas (° F.).		Temperature of gas leaving producer (° C.).		Volts.	Amperes.	Temperature of gas leaving producer (° C.).	Air entering (inches mer- cury).	Gas leaving (inches wa- ter).	Temperatures (° C.).			Cubic centimeters of water collected.	Cubic feet of gas.	B. T. U.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
			1.	2.	3.	4.	5.	6.						7.	8.	9.			10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
																																	Watt meter.	Ammeter.	1.	2.	Gas.	Inlet.	Outlet.	Water.	As read.	Standardized.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
4.50 p. m.	2,633,850																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

^a Test closed by lack of coal.

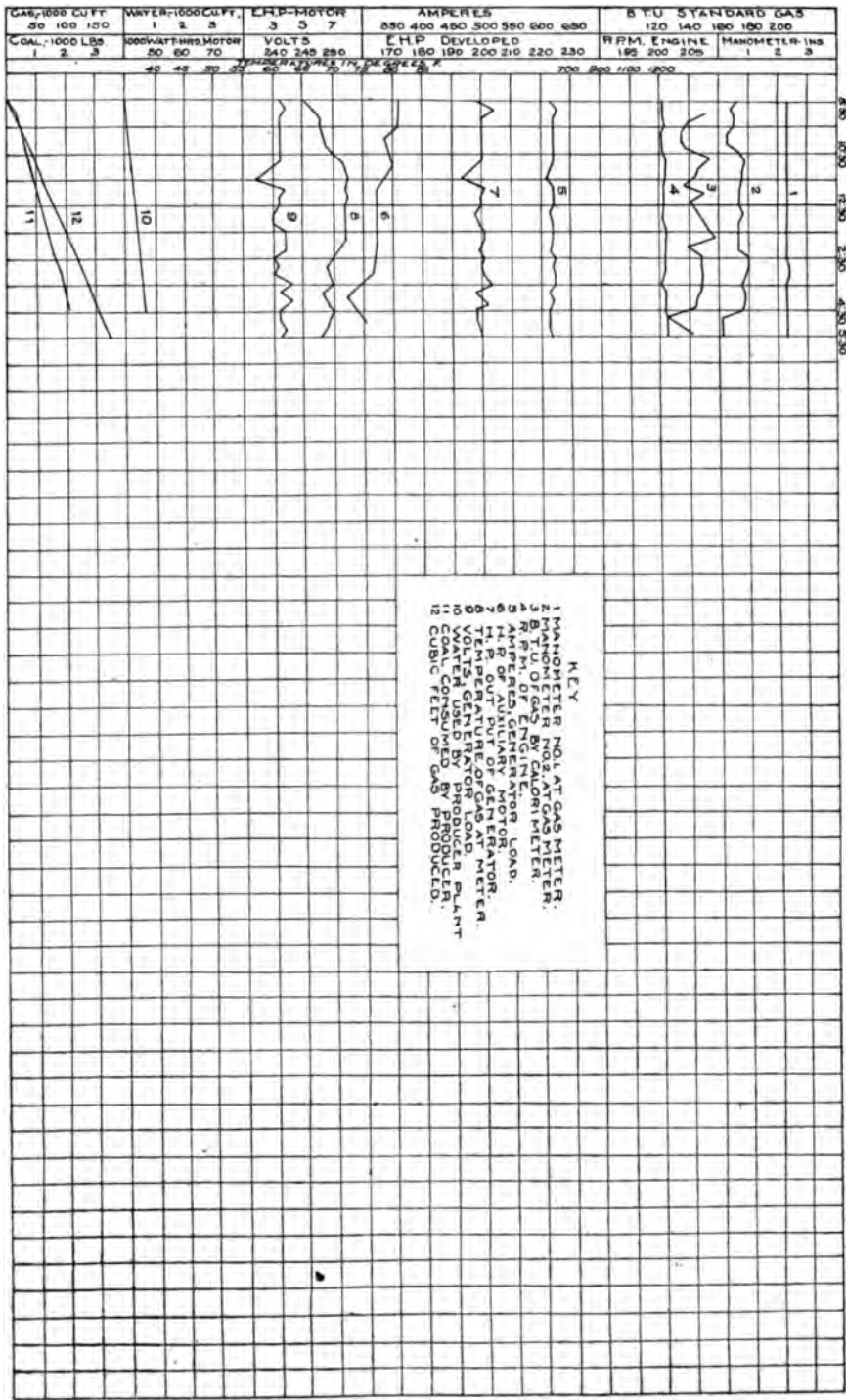


FIG. 128.—Graphic log sheet, producer-gas test, West Virginia No. 4 coal.

OPERATIONS OF THE COAL-TESTING PLANT.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
8.45 a. m.....	9.2	0.4	16.8	3.5	3.5	66.6	100.0	108.1
10.45 a. m.....	10.2	.4	15.1	10.5	4.1	59.7	100.0	132.9
12.10 p. m.....	11.0	.2	14.4	9.4	4.2	60.8	100.0	127.7
2.13 p. m.....	10.2	.2	16.6	14.5	3.4	55.1	100.0	144.6
4.10 p. m.....	10.2	.0	16.2	17.9	3.5	52.2	100.0	156.1

Producer-gas test No. 4, West Virginia No. 4 coal.

[Recorded by M. H. Mount and R. E. Peshak, October 20, 1904.]

1. Duration of test, in hours	9
AVERAGE TEMPERATURE, ° F.	
2. Gas leaving producer.....	804
3-6. (See footnote on p. 1027.)	
OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
7. Total steam used by producer.....pounds..	2,119
8. Steam used by producer per hour.....do....	235.6
9. Equivalent in pounds of coal per hour.....	29.78
10. Equivalent in pounds of dry coal per hour.....	29.15
11. Equivalent in pounds of combustible per hour.....	26.50
12. Average horsepower required to drive auxiliary machinery.....	10.5
13. Total water used in scrubber and tar extractor.....cubic feet..	744
14. Cubic feet of water per hour per horsepower of producer plant.....	.33
15. Cubic feet of water per 1,000 cubic feet of gas produced.....	4.45
COAL CONSUMED IN PRODUCER.	
16. Total coal consumed.....pounds..	2,100
17. Moisture in coal.....per cent..	1.99
18. Total dry coal consumed.....pounds..	2,058.2
19. Refuse from dry coal.....per cent..	9
20. Total refuse from coal.....pounds..	184.9
21. Total combustible consumed.....do....	1,873.3
COAL PER HOUR.	
22. Coal consumed in producer.....pounds..	233
23. Dry coal consumed in producer.....do....	229
24. Combustible consumed in producer.....do....	208
25. Equivalent coal used by producer plant.....do....	262.8
26. Equivalent dry coal used by producer plant.....do....	258.2
27. Equivalent combustible used by producer plant.....do....	234.5

PRODUCER-GAS TESTS.

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COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired.....	pounds..	6.05
29. Dry coal.....	do....	5.96
30. Combustible	do....	5.40

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	13,918
32. Per pound of dry coal.....	14,202
33. Per pound of combustible.....	15,600
34. From coal as fired, per hour.....	3,250,000
35. From dry coal, per hour.....	3,250,000
36. From combustible, per hour.....	3,250,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	167,000
38. Per hour.....	18,560
39. Per pound coal consumed in producer.....	79.6
40. Per pound dry coal consumed in producer.....	81.2
41. Per pound combustible consumed in producer.....	89.2
42. Per pound equivalent coal used by producer plant.....	70.6
43. Per pound equivalent dry coal used by producer plant.....	71.9
44. Per pound equivalent combustible used by producer plant.....	79.2

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	143.2
46. Per pound dry coal burned in producer.....	11,610
47. Per hour per brake horsepower.....	11,320

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	189.2
49. Electrical horsepower developed at switch board.....	199.7
50. Brake horsepower available for outside purposes.....	222.5
51. Brake horsepower developed at engine.....	235

EFFICIENCIES.

52. Of conversion and cleaning gas.....	.82
53. Of producer plant.....	.72

OPERATIONS OF THE COAL-TESTING PLANT.

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	1. 23	1. 21	1. 10
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	1. 17	1. 15	1. 04
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	1. 05	1. 03	. 935
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	. 992	. 975	. 885
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	1. 39	1. 36	1. 24
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	1. 32	1. 29	1. 17
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	1. 18	. 1. 16	1. 05
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	1. 12	1. 10	. 998

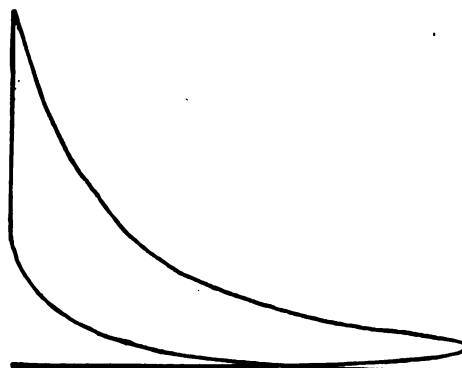
^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

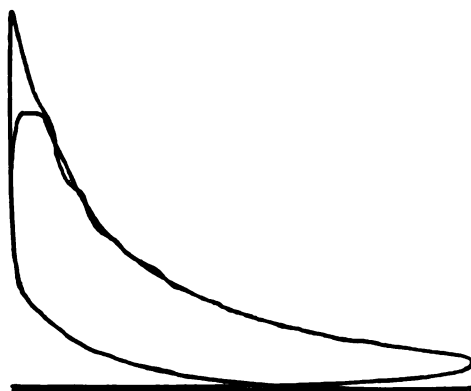
62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	1. 99	Carbon dioxide (CO ₂).....	10. 16
Volatile matter.....	28. 89	Oxygen (O ₂).....	. 24
Fixed carbon.....	60. 30	Carbon monoxide (CO).....	15. 82
Ash.....	8. 82	Hydrogen (H ₂).....	11. 16
	100. 00	Methane (CH ₄).....	3. 74
		Nitrogen (N ₂).....	58. 88
Sulphur.....	. 79		100. 00

The test was closed on account of insufficient supply of coal.

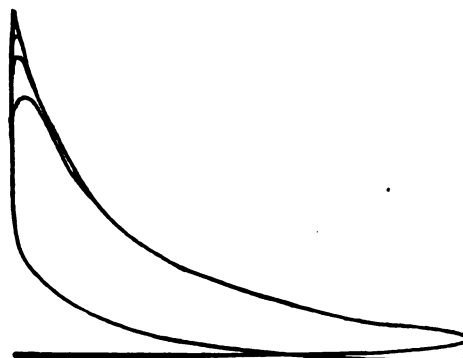
This coal is soft and friable, reaching the producer mainly as slack. It coked well on top of the bed and was readily worked. It promised to give the largest yield of gas of all the coals used thus far. Owing to the small supply of coal



Right cylinder. M. E. P., 62; Max., 280; Rel., 32; I. H. P., 97.7.



Center cylinder. M. E. P., 62; Max., 288; Rel., 30; I. H. P., 97.7.



Left cylinder. M. E. P., 54; Max., 250; Rel., 28; I. H. P., 85.1.

Indicator diagrams taken October 20, 1904, during gas-engine test No. 4, on West Virginia No. 4 coal. Scale of spring, 80; revolutions per minute, 200.2.

available the test was necessarily of short duration, but enough was done to show that it is an excellent gas-producer coal.

The indicator cards shown for this test are good representatives of all the cards taken for this run. The ignition setting is good.

GAS ENGINE.

Following are results of tests by gas engine:

Report of gas-engine test No. 4.

Recorded by R. W. Cummings and W. C. Weidmann, October 20, 1904.	
Producer test No. 4.	
Coal: General number, West Virginia No. 4; special number, G. P. 4. Car initials and number, B. and O. 4416.	
Duration of test, in hours	9
Revolutions per minute (mean).....	200.7
Explosions per minute (mean).....	100.3
Cubic feet gas per hour, by meter.....	19,200
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	18,550
Maximum pressure:	
First cylinder.....	269.6
Second cylinder.....	285
Third cylinder.....	268.5
Pressure at release:	
First cylinder.....	31
Second cylinder.....	33.2
Third cylinder.....	29.2
Mean effective pressure:	
First cylinder.....	62.6
Second cylinder.....	65
Third cylinder.....	55.2
Indicated horsepower:	
First cylinder.....	98.9
Second cylinder.....	102.8
Third cylinder.....	87.1
Total indicated horsepower.....	288.8
Horsepower delivered (electrical horsepower).....	199.7
Mechanical efficiency (engine and generator combined)..... per cent..	69
Cubic feet standard gas per hour per indicated horsepower.....	64.3
Cubic feet standard gas per hour per electrical horsepower.....	93

WEST VIRGINIA No. 7.

GENERAL RESULTS.

The general results of tests of West Virginia No. 7 coal are shown in the following tables:

Log of producer-gas test No. 23, West Virginia No. 7 coal, February 2, 3, 1905.
[Coal from mine of the New River Smokeless Coal Company, Sun, W. Va.]

Time.	Coal consumed by producer (pounds).	Manometers at gas meter (inches water).				Auxiliary motors.		Speed counters on gas engine.		Load.	Temperature of gas leaving producer (°C.).	Manometers at producer.		Temperatures (°C.).				Gas calorimeter.				B. T. U. Standardized.		
		Water meter (cubic feet).		Gas meter (cubic feet).		Watt meter.		Ammeter.				Volts.		Amperes.		Gas.		Water.		Cubic centimeters of water collected.			Cubic feet of gas.	
		1.	2.	1.	2.	1.	2.	1.	2.			1.	2.	1.	2.	1.	2.	1.	2.	1.	2.		1.	2.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
9.10 a. m. a.		482,300	40	57,320	2.2	0.4	135,900		149,230	239	634	540										(b)		
9.30 a. m.		489,250	47		2.2	.5			151,237	239	634	610										(b)		
9.50 a. m.		486,100	51		2.2	.2			153,273	239	624	660		0.6	6.5							(b)		
10 a. m.	300																							
10.10 a. m.		503,100	53		2.3	.6	138,100		155,320	238	624	640										(b)		
10.30 a. m.		509,780	55		2.3	.6			157,372	240	624	680				2.0	4.2	8.8	730	0.1	132.0	125.4		
10.50 a. m.		516,800	56		2.3	.2			159,400	241	624	670				8.0	4.2	9.2	720	.1	142.8	136.8		
11 a. m.	300																							
11.10 a. m.		524,120	58		2.1	.1	140,400		161,424	239	624	680				9.0	4.3	9.2	720	.1	136.7	134.1		
11.30 a. m.		531,680	59		2.1	.2			163,452	238	614	670		.65	7.0	11.0	4.3	9.5	750	.1	154.7	149.6		
11.50 a. m.		539,150	60		2.0	.6			165,408	239	629	700										(b)		
12 m.	300																							
12.10 p. m.		546,700	62		2.1	.2	142,700		167,404	241	624	680				12.0	4.0	9.4	720	.1	154.0	149.5		
12.30 p. m.		554,000	62		2.1	.2			169,525	240	614	650		.5	6.0	13.0	4.0	9.9	710	.1	165.9	161.4		
12.50 p. m.		561,300	63		2.1	.4			171,569	238	629	660				13.5	4.0	9.8	700	.1	181.3	176.2		
1.10 p. m.		568,400	63		2.2	.4	144,930		173,583	239	624	670				14.5	4.2	9.7	780	.1	170.2	166.1		
1.15 p. m.	300																							
1.30 p. m.		575,250	63		2.2	.5			175,608	240	619	650		.5	6.0	14.5	4.2	9.9	780	.1	176.2	171.8		
1.50 p. m.		581,990	63		2.3	.8			177,638	240	634	650				15.5	4.4	10.3	750	.1	175.7	162.5		
2.10 p. m.		588,700	64	58,264	2.2	.4	147,340		179,669	238	629	660				14.0	4.2	9.4	830	.1	178.9	174.3		
2.30 p. m.		595,600	63		2.2	.4			181,695	239	585	680				13.5	4.2	9.0	820	.1	161.9	157.4		
2.40 p. m.	300																							
2.50 p. m.		602,540	64		2.3	.4			183,718	238	634	610		.5	6.0	13.5	4.2	8.9	830	.1	154.7	150.4		
3.10 p. m.		609,200	64		2.3	.6	149,410		185,750	239	629	620				13.5	4.2	9.2	840	.1	170.6	165.9		

^a February 2. Average barometer for entire test, 30.73 inches.

^b Water pipe to calorimeter frozen.

Log of producer-gas test No. 23, West Virginia No. 7 coal, February 2, 3, 1905—Continued.

Time.	Coal consumed by producer (pounds).	Auxiliary motors.										Speed counters on gas engine.		Load.		Manometers at producer.	Temperatures (°C.).				Gas calorimeter.		B. T. U.		
		Manometers at gas meter (inches water).		Watt meter.		Ammeter.	1.		2.	Volts.		Amps.	Temperature of gas leaving producer (°C.).	Air entering (inches mercury).	Gas leaving (inches mercury).		Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.			Standardized.
		1.	2.	8.	9.		10.	11.		12.	13.															14.	15.	16.	17.	18.	19.	20.	21.	22.	23.
3.30 p. m.		615,810	64							187,782	238	624	630				13.0	4.2	8.9	910	0.1	169.4	164.4		
3.50 p. m.		622,520	64							189,813	240	629	650				13.0	4.2	8.7	980	.1	174.5	169.5		
4 p. m.	300																								
4.10 p. m.		629,180	64	58,620	2.3	.5	151,500			191,846	240	624	580	0.3	5.5	12.5	4.0	8.2	1,100	.1	183.3	179.6			
4.30 p. m.		635,650	64		2.3	.5				193,881	240	624	610			13.0	4.2	10.1	740	.1	171.8	166.8			
4.50 p. m.		642,120	64		2.4	.8				195,919	240	619	620			12.0	4.2	10.4	690	.1	169.4	165.0			
5.10 p. m. a.		648,030	64		2.4	.9	153,420			197,957	240	614	640			12.0	4.3	9.7	850	.1	182.1	176.6			
5.20 p. m.	300																								
5.30 p. m.		654,460	64		2.4	.8				199,972	240	619	600	.3	6.0	11.0	4.3	10.0	720	.1	189.9	183.4			
5.50 p. m.		660,400	64		2.4	.8				202,006	240	614	630			12.5	4.4	10.0	730	.1	181.8	157.0			
6.10 p. m.		666,580	64	58,972	2.4	.5	155,430			204,035	240	624	640			11.0	4.2	9.4	830	.1	171.0	165.3			
6.30 p. m.	300	673,000	64		2.3	.6				206,058	241	629	660			11.0	4.3	8.7	1,000	.1	174.6	168.7			
6.50 p. m.		679,250	64		2.4	.7				208,092	241	619	650			12.0	4.3	9.1	910	.1	173.4	167.8			
7.10 p. m.		685,450	64		2.3	.6	157,400			210,110	240	624	660	.6	7.0	12.0	4.3	8.7	990	.1	173.0	167.5			
7.30 p. m.	300	692,000	64		2.2	.0				212,128	241	619	660			12.0	4.4	8.6	1,000	.1	166.6	161.3			
7.50 p. m.		699,100	64		2.2	.0				214,157	240	619	710			12.5	4.4	8.6	1,000	.1	166.6	161.6			
8.10 p. m.		706,150	64	59,410	2.2	.0	159,600			216,180	240	624	650			12.5	4.3	9.7	760	.1	162.7	157.8			
8.15 p. m.	300																								
8.30 p. m.		713,200	64		2.2	.1				218,210	241	624	620	.5	6.5	12.5	4.3	9.2	880	.1	171.0	165.9			
8.50 p. m.		720,400	64		2.2	.0				220,234	241	624	630			12.5	4.4	8.8	1,010	.1	176.2	170.9			
9.10 p. m.		727,650	64		2.0	.4	161,600			222,250	239	624	660			12.5	4.3	10.5	590	.1	145.2	140.9			
9.15 p. m.	300																								
9.30 p. m.		735,200	63		2.0	.5				224,266	240	619	650	.4	5.0	12.5	4.2	10.2	600	.1	142.8	138.5			
9.50 p. m.		743,000	63		2.0	.8				226,275	238	624	640			12.0	4.3	9.5	670	.1	134.1	129.7			
10.10 p. m.	300	751,550	63		2.0	.8	163,800			228,285	239	624	660			12.0	4.4	9.5	700	.1	141.6	136.9			

a At 5.15 p. m. the engine igniters were working badly. The load was reduced for two minutes.

Log of producer-gas test No. 23, West Virginia No. 7 coal, February 2, 3, 1906—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Gas calorimeter.				B. T. U.				
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Temperatures (° C.).		Cubic centimeters of water collected.			Cubic feet of gas.		
																	Inlet.	Outlet.						
																							Water.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
10.30 p. m.	300	768,650	63			2.0	-0.9			230,202	238	624	730			12.5	4.3	9.6	660	0.1	138.8	134.7		
10.50 p. m.		705,960	63			2.0	- .9			232,307	238	619				12.5	4.2	9.3	680	.1	137.7	133.6		
11.10 p. m.		773,700	63			2.0	- .6	166,050		234,312	243	614	580	0.5	7.0	12.5	4.2	9.4	750	.1	158.7	153.9		
11.30 p. m.		781,300				2.0	- .8			236,312	240	624	710			12.5	4.3	9.3	830	.1	162.6	157.8		
11.45 p. m.	300																							
11.50 p. m.		786,000	64			2.0	- .8			238,325	240	624	630			13.0	4.3	9.1	770	.1	146.8	142.6		
12.10 a. m. ^a		796,570	64	59,978		2.1	- .3	168,250		240,342	242	634	660			12.5	4.3	9.2	840	.1	163.1	158.3		
12.30 a. m.		804,210	64			1.9	- .5			242,372	239	575	720	.4	6.0	11.5	4.3	8.9	890	.1	162.6	157.1		
12.50 a. m.		811,860	64			2.0	- .4			244,384	239	619	710			12.5	4.3	9.8	670	.1	142.0	137.7		
1.10 a. m.		819,550	64			2.0	- .5	170,220		246,397	238	624	750			13.0	4.3	10.0	630	.1	146.8	142.5		
1.30 a. m.		827,330	64			2.0	- .3			248,411	237	619	700			12.5	4.4	9.6	660	.1	136.1	132.1		
1.50 a. m.		834,870	64			2.0	- .2			250,435	240	604	730			12.5	4.3	10.5	620	.1	152.4	147.8		
2 a. m.	300																							
2.10 a. m.		842,690	65			2.0	- .8	172,250		252,454	235	614	640	.2	6.5	13.0	4.2	10.0	720	.1	165.5	160.7		
2.30 a. m.		850,980	65			1.9	-1.1			254,459	235	629	720			13.0	4.3	9.9	690	.1	153.2	148.7		
2.50 a. m.		859,380	65			2.0	- .9			256,456	240	594	740			12.5	4.2	10.2	640	.1	150.8	146.3		
3 a. m.	300																							
3.10 a. m.		867,810	65			2.4	+1.0	174,390		258,479	243	619	640			13.0	4.3	11.2	510	.1	139.7	135.6		
3.30 a. m.		873,590	65			2.4	1.1			260,503	244	575	650			12.5	4.3	11.6	570	.1	165.1	160.1		
3.50 a. m.		879,440	65			2.4	.8			262,533	241	619	650			13.0	4.3	10.2	720	.1	168.2	163.3		
4 a. m.	300																							
4.10 a. m.		885,900	65			2.4	.6	176,400		264,551	241	614	590			13.0	4.2	9.4	840	.1	173.4	168.3		
4.30 a. m.		892,240	64			2.4	.4			266,576	241	614	640			13.0	4.2	11.6	500	.1	146.8	142.6		
4.50 a. m.		898,730	64			2.4	.8			268,607	240	614	670			12.5	4.2	11.2	530	.1	147.2	142.8		
5.10 a. m.		905,400	64			2.4	.4	178,420		270,631	238	614	730			13.0	4.2	10.5	610	.1	152.4	147.9		

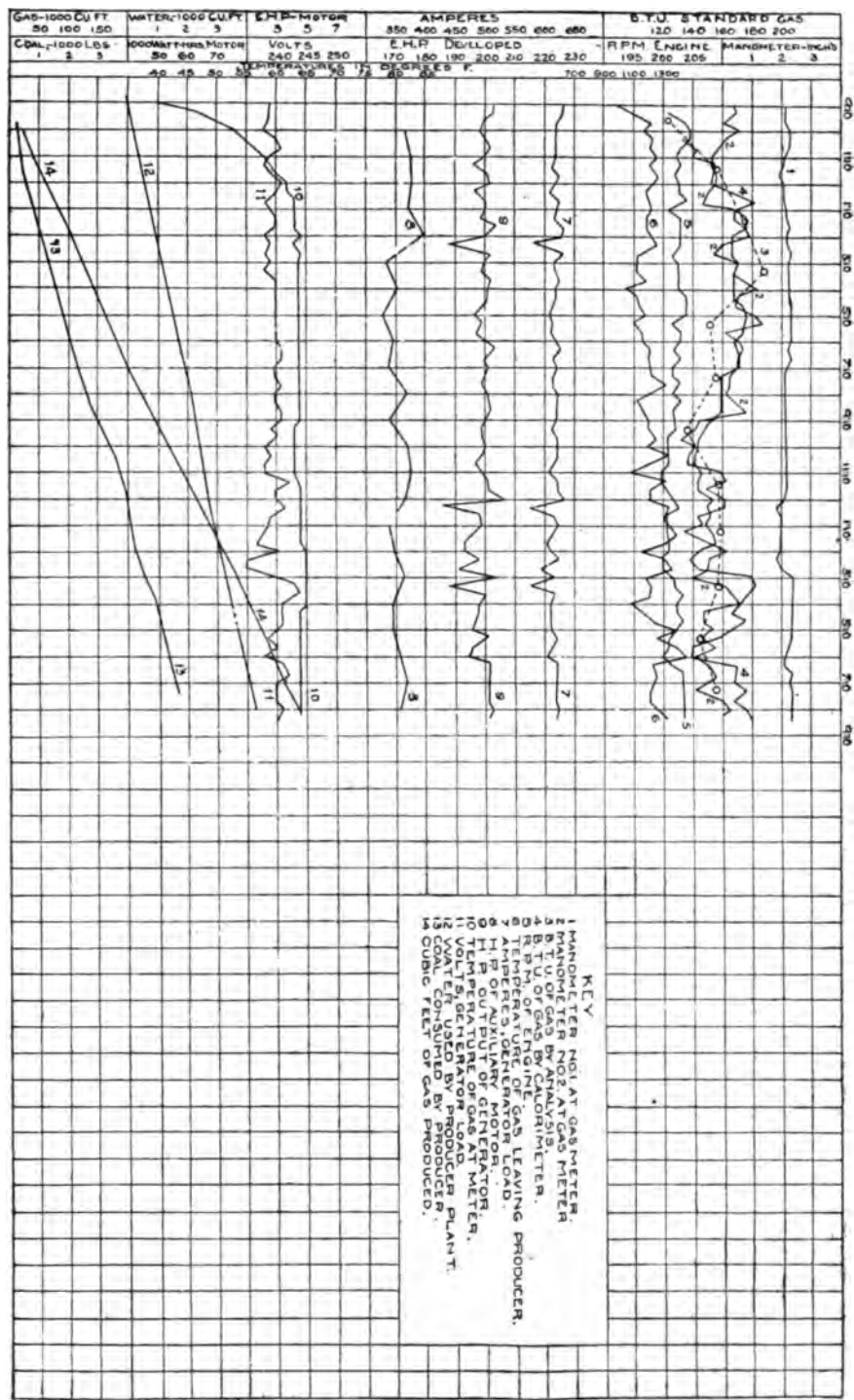
a February 2

Log of producer-gas test No. 23, West Virginia No. 7 coal, February 2, 3, 1905—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.	Gas calorimeter.					B. T. U.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
				1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.			Air entering (inches mer. cu. ft.).	Gas leaving (inches water).	Gas.	Temperatures (° C.).		Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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5.15 a. m.	300																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

^a At 8.50 a. m. the igniter rod on the engine broke, causing the engine to stop suddenly.

FIG. 129.—Graphic log sheet, producer-gas test, West Virginia No. 7 coal.



OPERATIONS OF THE COAL-TESTING PLANT.

GAS ANALYSES.

Time.	CO ₂	O ₂	CO.	H ₂	CH ₄	N.	Total.	B. T. U.
9.40 a. m. ^a	5.2	0.0	13.0	6.0	5.5	70.3	100.0	124.8
11.40 a. m.....	9.8	0.0	10.2	10.1	6.2	63.7	100.0	156.7
1.40 p. m.....	9.6	0.4	15.8	10.9	7.6	55.7	100.0	174.9
3.40 p. m.....	9.8	0.2	15.8	11.2	7.4	55.6	100.0	189.3
5.40 p. m.....	10.0	0.4	15.2	8.9	6.5	59.0	100.0	153.2
7.40 p. m.....	10.4	0.0	13.6	10.9	6.7	58.4	100.0	156.8
9.40 p. m.....	10.8	0.0	11.0	8.8	6.3	63.1	100.0	136.1
11.40 p. m.....	10.8	0.0	10.0	15.8	6.3	57.1	100.0	156.9
1.40 a. m. ^b	10.4	0.0	10.6	13.9	6.9	58.2	100.0	158.8
3.40 a. m.....	8.6	0.0	13.2	9.2	7.4	61.6	100.0	156.9
5.40 a. m.....	10.8	0.0	11.0	9.4	6.9	61.9	100.0	144.6
7.40 a. m.....	9.2	0.0	13.6	8.6	7.4	61.2	100.0	156.2

^a February 2.

^b February 3.

Producer-gas test No. 23, West Virginia No. 7 coal.

[Recorded by W. C. Weidmann and Kurt Toensfeldt, February 2, 3, 1905.]

1. Duration of test, in hours 22. 67

AVERAGE TEMPERATURE, ° F.

2. Gas leaving producer..... 1, 228

3-6. (See footnote on p. 1027.)

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

7. Total steam used by producer.....pounds.. 6, 260

8. Steam used by producer per hour.....do.... 276

9. Equivalent, in pounds, of coal per hour 34. 3

10. Equivalent, in pounds, of dry coal per hour 33. 3

11. Equivalent, in pounds, of combustible per hour 31.

12. Average horsepower required to drive auxiliary machinery 11. 4

13. Total water used in scrubber and tar extractor.....cubic feet.. 4, 269

14. Cubic feet of water per hour per horsepower of producer plant..... .75

15. Cubic feet of water per 1,000 cubic feet of gas produced..... 8. 63

COAL CONSUMED IN PRODUCER.

16. Total coal consumed.....pounds.. 6, 000

17. Moisture in coal.....per cent.. 2. 99

18. Total dry coal consumed.....pounds.. 5, 820

19. Refuse from dry coal.....per cent.. 6. 87

20. Total refuse from coal.....pounds.. 400

21. Total combustible consumed.....do.... 5, 420

PRODUCER-GAS TESTS.

1255

COAL PER HOUR.

22. Coal consumed in producer.....	pounds..	264. 9
23. Dry coal consumed in producer.....	do....	256. 9
24. Combustible consumed in producer.....	do....	239. 1
25. Equivalent coal used by producer plant.....	do....	299. 2
26. Equivalent dry coal used by producer plant.....	do....	290. 2
27. Equivalent combustible used by producer plant.....	do....	270. 1

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired	pounds..	6. 88
29. Dry coal	do....	6. 68
30. Combustible	do....	6. 22

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	14,283
32. Per pound of dry coal.....	14,720
33. Per pound of combustible.....	15,800
34. From coal as fired, per hour.....	3,780,000
35. From dry coal, per hour.....	3,780,000
36. From combustible, per hour.....	3,780,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	494,990
38. Per hour.....	21,850
39. Per pound coal consumed in producer.....	82. 5
40. Per pound dry coal consumed in producer.....	85. 1
41. Per pound combustible consumed in producer.....	91. 4
42. Per pound equivalent coal used by producer plant.....	73
43. Per pound equivalent dry coal used by producer plant.....	75. 3
44. Per pound equivalent combustible used by producer plant.....	80. 9

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	154. 2
46. Per pound dry coal burned in producer.....	13,140
47. Per hour per brake horsepower.....	14,380

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	187. 7
49. Electrical horsepower developed at switch board.....	199. 1
50. Brake horsepower available for outside purposes.....	221
51. Brake horsepower developed at engine.....	234. 1

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	1. 41	1. 37	1. 27
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	1. 33	1. 29	1. 20
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	1. 20	1. 16	1. 08
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	1. 13	1. 10	1. 02
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	1. 59	1. 55	1. 44
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	1. 50	1. 46	1. 36
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	1. 35	1. 31	1. 22
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	1. 28	1. 24	1. 15

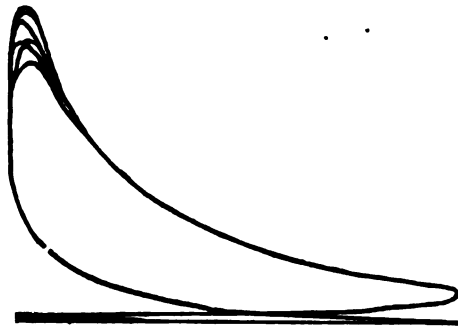
^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

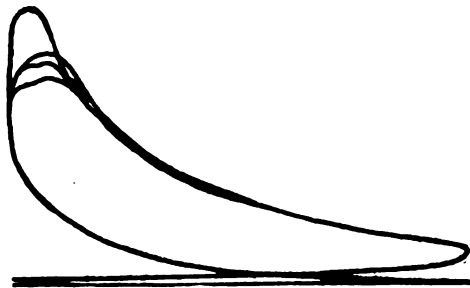
62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	2. 99	Carbon dioxide (CO ₂).....	9. 62
Volatile matter.....	21. 19	Oxygen (O ₂).....	. 08
Fixed carbon.....	69. 15	Carbon monoxide (CO).....	12. 75
Ash.....	6. 67	Hydrogen (H ₂).....	10. 31
	100. 00	Methane (CH ₄).....	6. 76
		Nitrogen (N ₂).....	60. 48
Sulphur.....	. 92		100. 00

This is a good, rich coal, like all the West Virginia coals tested. It is an excellent producer fuel, yielding a rich, uniform gas and good black tar.

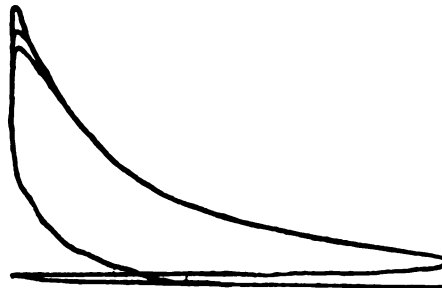
The run was interrupted by the breaking of one of the ignitor trip-stems on the engine.



Right cylinder. M. E. P., 62; Max., 300; Rel., 28; I. H. P., 96.9.



Center cylinder. M. E. P., 60; Max., 300; Rel., 29; I. H. P., 96.



Left cylinder. M. E. P., 55; Max., 290; Rel., 28; I. H. P., 88.

Indicator diagrams taken February 2, during gas-engine test No. 23, on West Virginia No. 7 coal. Scale of spring, 80; revolutions per minute, 202.6.

As may be seen by the indicator cards, the ignition was late in the right and center cylinders.

On account of the time of charging the producer with coal, the report does not include the first forty minutes recorded on the log sheets, which makes the official test 22.67 hours long.

GAS ENGINE.

Following are results of tests by gas engine:

Report of gas-engine test No. 23.

Recorded by W. C. Weidmann and K. Toensfeldt, February 2, 3, 1905.

Producer test No. 23.

Coal: General number, West Virginia No. 7; special number, G. P. 23. Car initials and number, C. and O. 12010.

Duration of test, in hours.....	22½
Revolutions per minute (mean).....	202.3
Explosions per minute (mean).....	101.15
Cubic feet gas per hour, by meter.....	21,290
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	21,840
Maximum pressure:	
First cylinder.....	238
Second cylinder.....	217
Third cylinder.....	271
Pressure at release:	
First cylinder.....	26
Second cylinder.....	27.5
Third cylinder.....	25.7
Mean effective pressure:	
First cylinder.....	58.5
Second cylinder.....	59
Third cylinder.....	52
Indicated horsepower:	
First cylinder.....	93.56
Second cylinder.....	94.10
Third cylinder.....	84.31
Total indicated horsepower.....	271.97
Horsepower delivered (electrical horsepower).....	199.1
Mechanical efficiency (engine and generator combined).....per cent..	73.2
Cubic feet standard gas per hour per indicated horsepower.....	80.3
Cubic feet standard gas per hour per electrical horsepower.....	109.7

WEST VIRGINIA No. 8.

GENERAL RESULTS.

The general results of tests of West Virginia No. 8 coal are shown in the following tables.

Log of producer-gas test No. 19, West Virginia No. 8 coal, January 20, 21, 1906.
[Coal from mine of the Gauley Mountain Coal Company, Ansted, W. Va.]

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.		Temperatures (° C.).				Cubic feet of gas.		B. T. U.	
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	As read.	Standardized.		
8.40 a. m.	300	9,397,250	54		2.1	-0.6	906,710			0,000	240	624	540	0.6	5.0								
9.40 a. m.		9,404,580	58		2.1	-				2,027	239	629	480										
10 a. m.	300	9,411,100	63		2.2	+				4,038	239	639	500	.6	5.0								
10.20 a. m.		9,417,300	64		2.3	-.8	908,530			9,000	238	629	470										
10.40 a. m.		9,423,750	67		2.2	-				8,114	239	624	500	.6	5.0								
11 a. m.	300	9,430,480	68		2.1	-				10,137	239	629	510										
11.20 a. m.		9,437,320	69		2.2	-				12,158	238	624	500										
11.40 a. m.		9,444,000	69		2.2	+				14,185	239	619	500	.8	6.0								
12 m.	300	9,450,830	70		2.1	-				16,198	238	629	490										
12.20 p. m.		9,457,900	71		2.1	-				18,215	236	629	430										
12.40 p. m.		9,465,200	70		2.1	-				20,210	238	624	510										
1 p. m.		9,472,450	70		2.1	-				22,220	238	614	520	-.8	7.0								
1.20 p. m.		9,479,800	70		2.1	-				24,213	242	614	450										
1.40 p. m.	300	9,486,750	70		2.1	+				26,233	244	614	400										
2 p. m.		9,493,250	70		2.1	-.5				28,256	240	624	410										
2.20 p. m.	300	9,499,600	70		2.2	-.8				30,288	240	624	430	-.5	5.0								
2.40 p. m.		9,506,000	69		2.3	-.8	916,130			32,313	238	629	390										
3 p. m.	300	9,512,650	69		2.3	+				34,330	240	619	510										
3.20 p. m.		9,519,350	70		2.3	-.5	918,000			36,347	242	619	490										
3.40 p. m.		9,525,980	71		2.2	-				38,372	241	619	400										
4 p. m.					2.2	-																	
4.10 p. m.	300																						
4.20 p. m.		9,532,660	71		2.2	+				40,393	241	614											
4.40 p. m.		9,539,300	71		2.3	-				42,416	240	619	500										

^a January 20. Average barometer for entire test, 29.58 inches.

Log of producer-gas test No. 19, West Virginia No. 8 coal, January 20, 21, 1905—Continued.

Time.	Coal consumed by producer (pounds).		Gas meter (cubic feet).		Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.				Gas calorimeter.						B. T. U.			
																							Temperatures (° C.).		Cubic centimeters of water collected.		Cubic feet of gas.					
																							Water.		Gas.		Inlet.				Outlet.	
																							Gas.	Inlet.	Outlet.	Gas.	Inlet.	Outlet.			As read.	Standardized.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23										
5 p. m.		9,545,540	70		2.3	0.6				44,440	241	614	480			20.5	4.8	14.7	800	0.2	157.1		161.6									
5.15 p. m.	300																															
5.30 p. m.		9,551,620	70		2.3	.6				46,464	240	624	440			18.0	4.7	13.9	780	.2	142.1		144.8									
5.40 p. m.		9,557,530	69		2.3	.8	921,590			48,488	241	624	450			18.5	4.7	14.7	790	.2	156.7		159.8									
6 p. m.		9,563,330	69		2.3	.6				50,515	240	634	390			19.0	4.7	14.8	790	.2	158.3		162.0									
6.15 p. m.	300																															
6.30 p. m.		9,569,140	69		2.3	.6				52,542	241	624	400	0.6	5.0																	
6.40 p. m.		9,575,910	69		2.3	.6	923,400			54,569	241	624	460			16.5	4.7	13.9	850	.2	155.1		157.3									
7 p. m.		9,580,700	68		2.3	.6				56,596	240	619	480																			
7.15 p. m.	300																															
7.30 p. m.		9,586,500	68		2.3	1.0				58,618	243	575	410			17.5	4.8	14.3	800	.2	150.7		153.3									
7.40 p. m.		9,592,750	68		2.3	.6	925,150			60,634	239	624	480			16.0	4.7	12.8	840	.2	134.9		136.6									
8 p. m.	300	9,599,200	68		2.3	.6				62,645	240	624	450			17.8	4.8	13.4	870	.2	148.4		151.2									
8.20 p. m.		9,605,550	68		2.3	.6				64,653	240	624	520	.6	5.0	17.0	4.8	13.1	940	.2	154.7		157.2									
8.30 p. m.	300																															
8.40 p. m.		9,612,100	68		2.3	.6	927,000			66,666	240	619	400			17.0	4.8	14.1	830	.2	152.8		155.4									
8.45 p. m.	300																															
9 p. m.		9,618,450	69		2.3	.8				68,684	240	624		.6	5.0	17.0	4.8	14.2	860	.2	160.3		163.1									
9.20 p. m.		9,624,850	69		2.3	.8				70,703	241	594	470			16.3	4.8	13.3	880	.2	148.4		150.3									
9.30 p. m.	300																															
9.40 p. m.		9,631,250	69		2.3	.8				72,720	238	644	410			16.0	4.6	12.4	930	.2	143.6		146.2									
10 p. m.		9,637,720	69		2.3	.8				74,745	240	624	460			17.0	4.7	12.8	930	.2	146.2		151.7									
10.15 p. m.	300																															
10.20 p. m.		9,644,200	70		2.3	.6				76,755	238	650	410			16.5	4.7	12.4	1,000	.2	152.8		154.8									
10.40 p. m.		9,650,800	70		2.3	.6	930,500			78,766	240	634	450			16.5	4.7	12.7	1,000	.2	158.7		160.8									

Log of producer-gas test No. 10, West Virginia No. 8 coal, January 20, 21, 1905.—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.			Temperatures (° C.).				Gas calorimeter.		B. T. U.				
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mer- cury).	Gas leaving (inches wa- ter).	14	15	16	Gas.	Water.		Cubic centimeters of water collected.			Cubic feet of gas.	As read.	Standardized.
																				Inlet.	Outlet.						
																							17	18				19	20	21	22
1	300	9,657,200	70		2.3	0.6				80,782	240	624	480														
11 p. m.																											
11.05 p. m.																											
11.20 p. m.		9,663,500	70		2.3	.7				82,811	240	624	460	0.6	5.5	17.0	4.8	12.9	970	0.2	155.9	158.3					
11.40 p. m.		9,669,600	70		2.3	.8	932,200			84,828	239	634	440			17.0	4.7	12.7	1,050	.2	166.6	170.9					
11.45 p. m.	300																										
12 p. m.		9,675,510	70		2.4	.8				86,853	241	620	420			18.0	4.8	13.5	920	.2	158.7	161.9					
12.20 a. m. ^a		9,681,340	70		2.4	.8				88,876	241	614	480	.6	5.0	18.0	4.8	15.0	700	.2	153.9	157.1					
12.30 a. m.	300																										
12.40 a. m.		9,687,300	70		2.4	.7	934,050			90,806	241	619	450			18.0	4.8	14.8	750	.2	148.8	151.8					
1 a. m.		9,693,210	70		2.3	.7				92,919	239	634	400			19.0	4.8	15.3	770	.2	160.3	164.2					
1.15 a. m.	300																										
1.20 a. m.		9,699,350	70		2.4	.7				94,937	239	624	420	.6	4.5	18.0	4.8	15.2	720	.2	148.4	151.5					
1.40 a. m.		9,705,340	70		2.3	.9	935,840			96,959	241	614	440			18.0	4.8	15.6	690	.2	148.0	151.0					
2 a. m.	300	9,711,300	70		2.4	.8				98,982	240	624	450	.7	5.0	18.0	4.8	15.0	730	.2	147.6	150.6					
2.20 a. m.		9,717,360	70		2.3	.7				101,002	240	619	420			17.5	4.8	15.0	730	.2	147.6	150.2					
2.40 a. m.		9,723,410	70		2.3	.8	937,640			103,024	241	585	500			18.0	4.7	15.1	700	.2	144.4	147.2					
3 a. m.	300	9,729,190	70		2.4	.9				105,049	243	565	480	.5	4.0	17.5	4.8	15.4	700	.2	147.2	149.8					
3.20 a. m.		9,734,040	70		2.3	.3				107,071	239	634	450			17.5	4.8	13.2	850	.2	141.7	144.2					
3.40 a. m.		9,741,670	69		2.3	.6	939,220			109,070	241	629	510			17.5	4.8	13.2	850	.2	144.8	147.5					
4 a. m.		9,748,000	69		2.4	.8				111,092	242	609	530			17.5	4.8	14.6	740	.2	143.6	146.1					
4.15 a. m.	300																										
4.20 a. m.		9,754,220	70		2.3	.6				113,115	240	629	500			18.0	4.8	14.4	760	.2	144.8	147.4					
4.40 a. m.		9,760,400	69		2.3	.8	940,920			115,130	240	614	520	.6	5.0	18.0	4.8	14.2	800	.2	148.2	150.8					
5 a. m.		9,766,440	70		2.3	1.0				117,163	242	614	530			18.5	4.8	15.4	720	.2	151.6	154.7					

^a January 21.

Log of producer-gas test No. 19, West Virginia No. 8 coal, January 20, 21, 1905—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Temperatures (° C.).				Gas calorimeter.		B. T. U.	
			4	5	6	7	8	9	10	11	12	Volts.	Amperes.	Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.		
																							1	2
5.20 a. m.		9,772,580	69		2.3	1.0						119,188	242	61	540			18.5	4.8	14.8	740	0.2	146.8	150.2
5.30 a. m.	300																							
5.40 a. m.		9,778,800	69		2.3	1.0	942,580					121,208	240	624	470			18.0	4.9	14.8	750	.2	147.2	149.8
6 a. m.		9,784,900	69		2.3	.9						123,233	242	624	530			18.5	4.9	14.8	780	.2	153.2	156.3
6.20 a. m.		9,791,300	69.0		2.3	.8						125,253	240	629	550			18.5	4.8	13.8	820	.2	146.4	149.3
6.40 a. m.		9,798,200	69.0		2.4	.4	944,250					127,266	240	624	580			18.3	4.9	13.2	850	.2	143.2	146.2
6.45 a. m.	300																							
7 a. m.		9,805,000	69.0		2.4	.4						129,280	240	634	540			18.0	4.9	13.7	780	.2	136.1	138.7
7.20 a. m.		9,811,800	69.0		2.4	.2						131,295	240	614	620			18.0	5.0	12.7	900	.2	137.3	139.8
7.40 a. m.		9,819,100	69.0		2.4	.0	946,100					133,298	240	614	550			18.0	4.8	12.0	930	.2	132.9	135.3
8 a. m.		9,826,400	69.0		2.0	-1.0						135,306	240	575	610			18.0	4.7	11.5	920	.2	124.2	126.7
8.10 a. m.	300																							
8.20 a. m.		9,834,200	69.0		2.0	.8						137,321	240	538	580			18.2	4.7	12.1	940	.2	143.6	146.5
8.40 a. m.		9,841,350	69.0		2.1	.3	947,650					139,336	238	624	650			18.0	4.8	12.0	920	.2	133.3	135.8
9 a. m.		9,848,400	69.0		2.1	.6						141,328	236	564	650			18.0	4.7	11.2	1,080	.2	139.3	141.9
9.10 a. m.	300																							
9.20 a. m.		9,856,150	69.0		2.0	.8						143,311	242	524	670			6.0	17.6	4.7	960	.2	125.4	127.7
9.40 a. m.		9,863,300	69.0		2.0	.6	949,700					145,312	238	524	650			17.8	4.7	11.0	1,110	.2	138.5	141.0
10 a. m.		9,870,600	69.0		2.1	.0						147,314	242	424	580			17.8	4.6	12.4	820	.2	127.0	129.3
10.20 a. m.		9,877,800	69.0		2.1	.0						149,333	242	624	560			17.8	4.4	12.7	860	.2	146.4	148.9
10.40 a. m.		9,884,650	69.0		2.2	.2	951,100					151,351	241	634	560			18.0	4.3	12.9	880	.2	151.6	154.4
11 a. m.		9,891,650	70.0		2.1	.0						153,366	242	624	560			18.0	4.3	12.5	910	.2	148.0	151.1
11.20 a. m.		9,898,600	70.0		2.2	.4						155,380	243	624	550			17.8	4.2	13.2	800	.2	142.8	145.5
11.40 a. m.		9,905,000	70.5		2.2	.4	952,550					157,410	243	624	570			18.0	4.2	13.6	780	.2	145.6	148.6
12 m.		9,911,400	70.0		2.2	.6						159,440	242	624	560			18.0	4.2	13.5	820	.2	151.2	153.8

Log of producer-gas test No. 19, West Virginia No. 8 coal, January 20, 21, 1905—Continued.

[illegible]

OPERATIONS OF THE COAL-TESTING PLANT.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B.T.U.
9.45 a. m. ^a	7.4	0.0	13.2	6.2	7.0	66.2	100.0	142.3
11.45 a. m.	10.4	.2	11.6	10.8	5.5	61.5	100.0	136.6
1.45 p. m.	11.6	.4	10.6	9.0	6.1	62.3	100.0	133.3
3.45 p. m.	9.6	.6	13.4	8.4	6.6	61.4	100.0	139.9
5.45 p. m.	11.2	.2	12.8	11.0	6.1	58.7	100.0	147.6
7.45 p. m.	10.8	.2	11.6	10.5	5.5	61.4	100.0	139.6
9.45 p. m.	10.2	.2	13.0	9.7	6.3	60.6	100.0	146.2
11.45 p. m.	10.0	.0	12.2	11.2	6.2	60.4	100.0	147.6
1.45 a. m. ^b	10.8	.4	11.2	9.6	7.4	60.6	100.0	151.3
3.45 a. m.	11.0	.0	11.0	9.4	6.2	62.4	100.0	137.1
5.45 a. m.	10.6	.2	10.6	8.2	7.5	62.9	100.0	145.4
7.45 a. m.	11.4	.0	9.6	6.3	6.3	66.4	100.0	122.5
9.45 a. m.	13.2	.2	5.2	3.6	6.5	71.3	100.0	100.0
11.45 a. m.	10.4	.0	12.0	11.2	6.2	60.2	100.0	146.9
1.45 p. m.	9.6	.0	13.8	9.9	6.8	59.9	100.0	155.0

^a January 20.

^b January 21.

Producer-gas test No. 19, West Virginia No. 8 coal.

[Recorded by W. C. Weldmann and Kurt Toensfeldt, January 20, 21, 1905.]

1. Duration of test, in hours.....	21
AVERAGE TEMPERATURE, ° F.	
2. Gas leaving producer.....	847
3-6. (See footnote on p. 1027.)	
OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
7. Total steam used by producer.....pounds..	5,775
8. Steam used by producer per hour.....do....	275
9. Equivalent in pounds of coal per hour.....	36.1
10. Equivalent in pounds of dry coal per hour.....	35.1
11. Equivalent in pounds of combustible per hour.....	33
12. Average horsepower required to drive auxiliary machinery.....	9.6
COAL CONSUMED IN PRODUCER.	
16. Total coal consumed.....pounds..	6,900
17. Moisture in coal.....per cent..	2.66
18. Total dry coal consumed.....pounds..	6,720
19. Refuse from dry coal.....per cent..	5.92
20. Total refuse from coal.....pounds..	397.8
21. Total combustible consumed.....do....	6,322.2

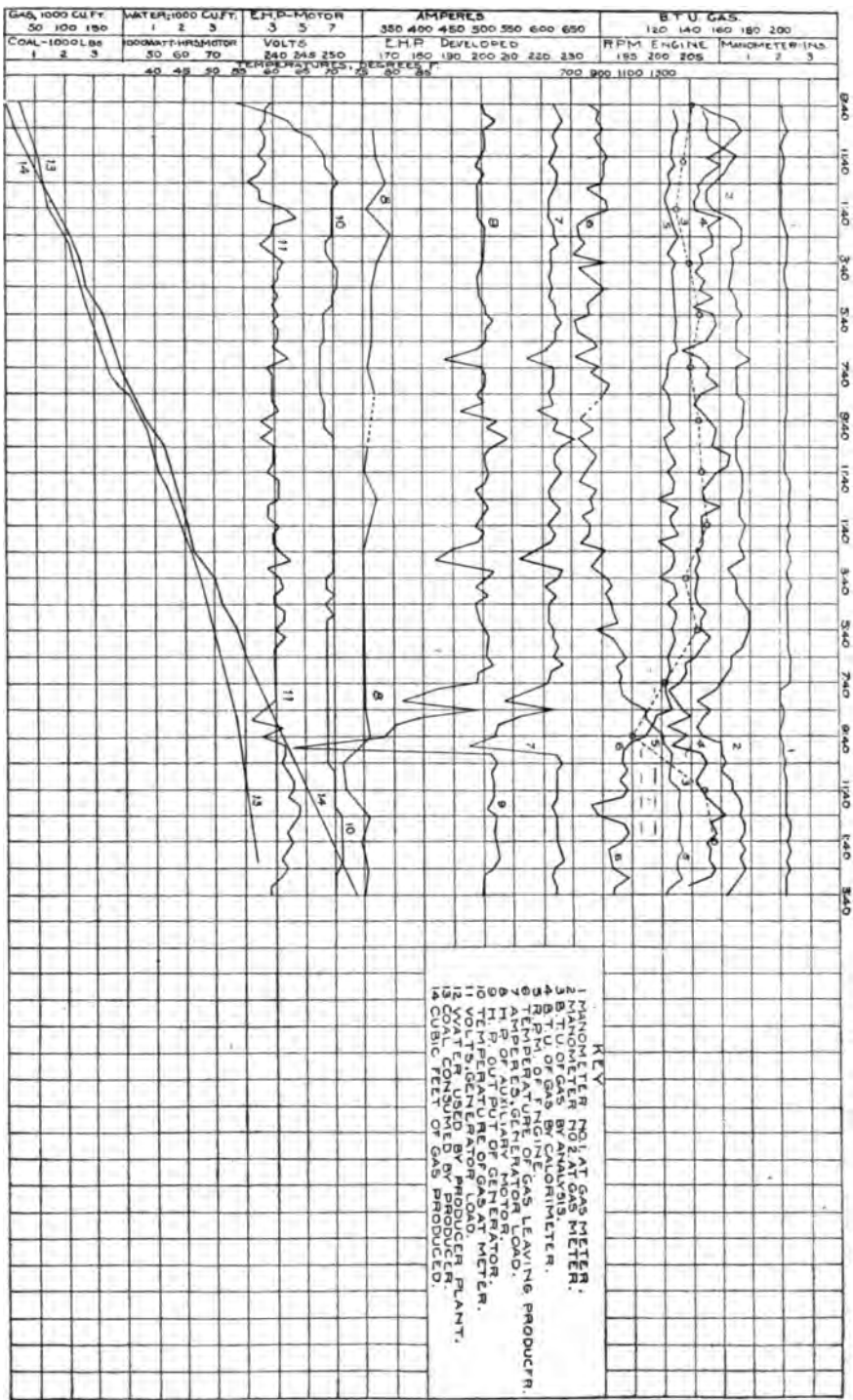


FIG. 130.—Graphic log sheet, producer-gas test, West Virginia No. 8 coal.

OPERATIONS OF THE COAL-TESTING PLANT.

COAL PER HOUR.

22. Coal consumed in producer.....	pounds..	328.6
23. Dry coal consumed in producer.....	do.....	320.1
24. Combustible consumed in producer.....	do.....	301.1
25. Equivalent coal used by producer plant.....	do.....	364.7
26. Equivalent dry coal used by producer plant.....	do.....	355.1
27. Equivalent combustible used by producer plant.....	do.....	334.1

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired.....	pounds..	8.54
29. Dry coal.....	do.....	8.32
30. Combustible.....	do.....	7.84

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	14,168
32. Per pound of dry coal.....	14,558
33. Per pound of combustible.....	15,470
34. From coal as fired, per hour.....	4,660,000
35. From dry coal, per hour.....	4,660,000
36. From combustible, per hour.....	4,660,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	392,240
38. Per hour.....	18,690
39. Per pound coal consumed in producer.....	56.9
40. Per pound dry coal consumed in producer.....	58.4
41. Per pound combustible consumed in producer.....	62
42. Per pound equivalent coal used by producer plant.....	51.3
43. Per pound equivalent dry coal used by producer plant.....	52.6
44. Per pound equivalent combustible used by producer plant.....	55.9

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	155.1
46. Per pound dry coal burned in producer.....	9,070
47. Per hour per brake horsepower.....	12,340

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	190.3
49. Electrical horsepower developed at switch board.....	199.9
50. Brake horsepower available for outside purposes.....	224
51. Brake horsepower developed at engine.....	235

EFFICIENCIES.

52. Of conversion and cleaning gas.....	.622
53. Of producer plant.....	.558

PRODUCER-GAS TESTS.

1267

COAL PER HORSEPOWER PER HOUR.

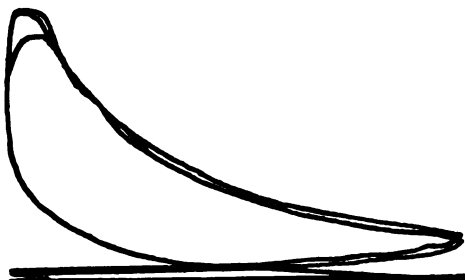
	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	1. 73	1. 68	1. 58
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	1. 64	1. 60	1. 51
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	1. 47	1. 43	1. 35
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	1. 40	1. 36	1. 28
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	1. 92	1. 87	1. 76
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	1. 82	1. 78	1. 67
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	1. 63	1. 59	1. 49
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	1. 55	1. 51	1. 42

^a Based on an assumed efficiency of 85 per cent for generator and belt.

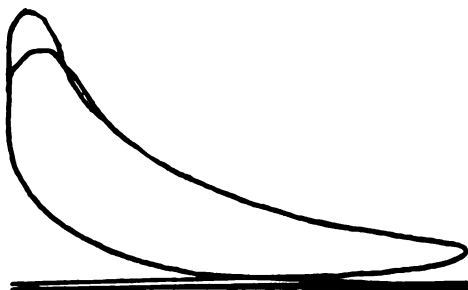
AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	2. 66	Carbon dioxide (CO ₂).....	10. 33
Volatile matter.....	32. 58	Oxygen (O ₂).....	22
Fixed carbon.....	59. 00	Carbon monoxide (CO).....	11. 93
Ash.....	5. 76	Hydrogen (H ₂).....	9. 45
	100. 00	Methane (CH ₄).....	6. 40
Sulphur.....	. 94	Nitrogen (N ₂).....	61. 67
			100. 00

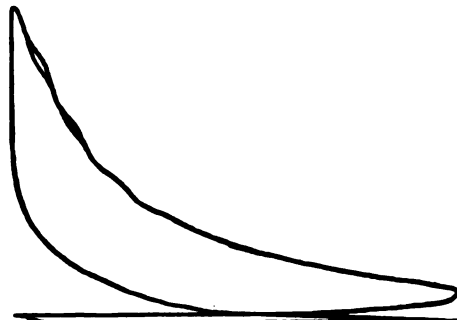
After the first twenty-one or twenty-two hours the load carried was somewhat irregular. On this account the report is made up from the records of the twenty-one hours from 9.40 a. m. January 20 to 6.40 a. m. January 21.



Right cylinder. M. E. P., 65; Max., 230; Rel., 30; I. H. P., 103.4.



Center cylinder. M. E. P., 63; Max., 230; Rel., 37; I. H. P., 100.2.



Left cylinder. M. E. P., 56; Max., 250; Rel., 36; I. H. P., 93.1.

Indicator diagrams taken January 20, 1905, during gas-engine test No. 19, on West Virginia No. 8 coal. Scale of spring, 80; revolutions per minute, 202.

This is a good producer coal, although it is hard to keep the fuel bed from getting hot on account of the large amount of pulverized coal in this particular sample. The gas was of good uniform quality. About 75 gallons of black tar were extracted.

PRODUCER-GAS TESTS.

1269

GAS ENGINE.

Following are results of tests by gas engine:

Report of gas-engine test No. 19.

Recorded by K. Toensfeldt and W. C. Weidmann, January 20, 21, 1905.

Producer test No. 19.

Coal: General number, West Virginia No. 8; special number, G. P. 19. Car initials and number, C. and O. 15945.

Duration of test, in hours.....	21
Revolutions per minute (mean).....	202
Explosions per minute (mean).....	101
Cubic feet gas per hour, by meter.....	19,090
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	18,680
Maximum pressure:	
First cylinder.....	238
Second cylinder.....	233
Third cylinder.....	257
Pressure at release:	
First cylinder.....	28
Second cylinder.....	29
Third cylinder.....	25.7
Mean effective pressure:	
First cylinder.....	60.5
Second cylinder.....	61.2
Third cylinder.....	53.3
Indicated horsepower:	
First cylinder.....	96.33
Second cylinder.....	97.40
Third cylinder.....	84.93
Total indicated horsepower.....	278.66
Horsepower delivered (electrical horsepower).....	199.9
Mechanical efficiency (engine and generator combined).....per cent..	71.7
Cubic feet standard gas per hour per indicated horsepower.....	67
Cubic feet standard gas per hour per electrical horsepower.....	93.5

WEST VIRGINIA No. 9.

GENERAL RESULTS.

The general results of West Virginia No. 9 coal are tabulated as follows:

Log of producer-gas test No. 17, West Virginia No. 9 coal, December 19, 1904.

[Coal from Vulcan mine of the Mount Carbon Coal Company (Limited), Powellton, W. Va.]

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.				Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.				Temperatures (° C.).		Gas calorimeter.		B. T. U.
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	Air entering (inches mercury).	Gas leaving (inches water).		Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
11.40 a. m. ^a		8,658,100	61.0		2.3	0.6	783,150			0,000	240	518	340											
12 m.	300	8,664,000	63.0		2.4	.9				2,027	240	518				27.0	5.0	13.2	940	0.2	152.8	158.4		
12.20 p. m.		8,669,300	65.0		2.5	1.1				4,058	239	518				25.8	4.9	13.1	960	.2	155.9	161.0		
12.40 p. m.		8,674,200	67.0		2.5	1.1	785,740			6,086	238	528	380	0.4	4.0	23.0	4.8	13.4	950	.2	161.9	166.8		
1 p. m.	300	8,679,170	67.0		2.5	1.2				8,111	236	538				22.0	5.0	13.0	980	.2	155.5	158.8		
1.20 p. m.		8,684,250	67.0		2.5	1.1				10,137	235	528				22.0	5.0	13.1	980	.2	157.1	160.3		
1.40 p. m.		8,689,260	68.0		2.4	1.1	798,420			12,160	240	518	390	.4	4.5	21.7	5.0	12.7	1,000	.2	152.7	155.7		
2 p. m.	300	8,694,540	69.0		2.5	1.0				14,168	239	518				20.8	5.0	12.7	1,000	.2	152.7	155.2		
2.20 p. m.		8,699,740	69.0		2.5	1.0				16,210	240	518				20.0	5.1	12.7	1,010	.2	153.0	155.0		
2.40 p. m.		8,704,760	68.0		2.5	1.0	801,130			18,238	240	518	400	.4	5.0	19.0	5.1	12.7	1,010	.2	153.0	153.2		
3 p. m.		8,710,000	68.0		2.5	1.0				20,262	241	528				19.0	5.1	13.65	850	.2	144.0	144.1		
3.20 p. m.		8,715,200	68.0		2.5	1.0				22,284	241	528				18.5	4.9	13.75	820	.2	143.6	144.8		
3.30 p. m.	300																							
3.40 p. m.		8,720,600	68.0		2.4	.5	803,580			24,312	240	518	460			18.0	4.8	12.8	850	.2	134.9	135.7		
4 p. m.		8,726,150	67.0		2.4	1.0				26,339	241	538				17.7	4.8	13.7	850	.2	150.0	150.8		
4.20 p. m.		8,731,510	67.5		2.4	.9				28,368	239	528				17.0	4.6	13.3	820	.2	141.3	141.7		
4.40 p. m.		8,737,100	67.0		2.4	.8	806,380			30,384	240	538	420			16.5	4.7	12.6	850	.2	133.0	133.2		
4.45 p. m.	300																							
4.50 p. m.		8,742,920	67.0		2.4	.8				32,404	240	523				16.5	4.8	12.3	940	.2	140.0	140.2		
5.20 p. m. ^b																								
5.40 p. m.		8,750,850	67.0		2.4	1.0	809,150			34,927	240	624	380			16.0	4.8	13.5	900	.2	155.1	155.9		
6 p. m.	300	8,756,380	65.5		2.4	.8				36,947	240	624				16.0	4.8	12.8	850	.2	134.9	135.6		
6.20 p. m.		8,761,950	65.0		2.4	.8				38,970	240	624				16.0	4.8	14.0	810	.2	147.6	148.4		

^a Average barometer for entire test, 29.78 inches. Test began at 9 a. m., but engine could not carry full load. At 9.20 a. m. one of the engine bearings was hot, necessitating further delay. Another start was made at 11.40 a. m. on a load of 500 amperes.
^b As the point of ignition was not right the engine was shut down for twenty minutes at 5.20 p. m. for the necessary change. The test was again started at 5.40 p. m. with full load on the engine.

Log of producer-gas test No. 17, West Virginia No. 9 coal, December 19, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Gas calorimeter.					B. T. U.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
6.40 p. m.	8,767,330	65.0	2.4	1.0	812,020	40,997	241	624	400	16.0	4.6	13.5	840	0.2	148.0	148.8	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
7 p. m.	8,772,670	65.0	2.4	1.0	812,020	40,997	241	624	400	16.0	4.6	13.5	840	0.2	148.0	148.8	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
7.20 p. m.	8,777,950	65.0	2.4	1.0	812,020	40,997	241	624	400	16.0	4.6	13.5	840	0.2	148.0	148.8	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
7.40 p. m.	8,783,150	64.5	2.4	1.0	814,400	47,063	241	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
8 p. m.	8,788,900	64.5	2.3	.6	816,200	49,138	241	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
8.20 p. m.	8,794,400	64.5	2.3	.6	816,200	51,159	240	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
8.40 p. m.	8,799,450	64.5	2.3	.5	816,200	53,188	238	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
9 p. m.	8,804,200	64.5	2.3	.5	816,200	55,208	240	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
9.20 p. m.	8,809,650	65.0	2.3	.5	819,100	57,235	238	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
9.40 p. m.	8,815,000	66.0	2.3	.5	819,100	59,262	238	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
10 p. m.	8,820,300	66.5	2.3	.4	819,100	61,290	240	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
10.15 p. m.	8,825,650	67.0	2.3	.4	822,000	63,319	237	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
10.20 p. m.	8,831,000	66.5	2.3	.4	822,000	65,348	240	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
10.40 p. m.	8,836,190	66.5	2.3	.4	822,000	67,381	240	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
11 p. m.	8,841,400	67.0	2.4	.5	824,920	69,419	238	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
11.20 p. m.	8,846,720	67.0	2.3	.2	824,920	71,457	240	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
11.30 p. m.	8,852,000	66.0	2.4	.5	824,920	73,495	242	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
11.40 p. m.	8,857,300	66.0	2.4	.5	824,920	75,533	242	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
12 p. m.	8,862,600	66.0	2.4	.5	824,920	77,571	242	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3
12.20 a. m.	8,867,900	66.0	2.4	.5	824,920	79,609	242	624	350	16.0	4.8	12.3	1,060	0.2	149.6	150.4	157.1	157.4	158.3	158.3	158.3	158.3	158.3	158.3	158.3	158.3

^a At 7.30 p. m. load was thrown off for five minutes as the engine was back firing badly. This was repeated at 8.45 p. m.
^b At 12.10 a. m. the igniters were working badly and the engine stopped.

PRODUCER-GAS TESTS.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
11.40 a. m.	10.2	0.0	10.2	5.8	6.4	67.4	100.0	123.8
2.05 p. m.	10.6	.2	11.6	13.5	6.2	57.9	100.0	152.6
4.05 p. m.	10.6	.8	11.8	13.4	6.0	57.4	100.0	151.5
6.05 p. m.	11.0	.2	13.0	10.0	6.1	59.7	100.0	145.1
8.05 p. m.	10.8	.0	13.8	9.0	6.8	59.6	100.0	152.9
10.25 p. m.	10.0	.4	13.6	10.1	6.4	59.5	100.0	151.0

Producer-gas test No. 17A,^a West Virginia No. 9 coal.

[Recorded by W. C. Weidmann, Kurt Toensfeldt, and R. E. Peshak, December 19, 1904.]

1. Duration of test, in hours 5.33

AVERAGE TEMPERATURE, ° F.

2. Gas leaving producer 752

3-6. (See footnote on p. 1027.)

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

7. Total steam used by producer pounds.. 1,253
8. Steam used by producer per hour do... 235.5
9. Equivalent in pounds of coal per hour 28.9
10. Equivalent in pounds of dry coal per hour 28.1
11. Equivalent in pounds of combustible per hour 26.5
12. Average horsepower required to drive auxiliary machinery 14.2

COAL CONSUMED IN PRODUCER.

16. Total coal consumed pounds.. 1,300
17. Moisture in coal per cent.. 2.66
18. Total dry coal consumed pounds.. 1,265
19. Refuse from dry coal per cent.. 5.89
20. Total refuse from coal pounds.. 74.5
21. Total combustible consumed do... 1,190.5

COAL PER HOUR.

22. Coal consumed in producer pounds.. 244
23. Dry coal consumed in producer do... 237.5
24. Combustible consumed in producer do... 223.5
25. Equivalent coal used by producer plant do... 273.9
26. Equivalent dry coal used by producer plant do... 265.6
27. Equivalent combustible used by producer plant do... 250

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired pounds.. 6.34
29. Dry coal do... 6.18
30. Combustible do... 5.81

^aTest No. 17 was divided into two parts, as explained on p. 1275.

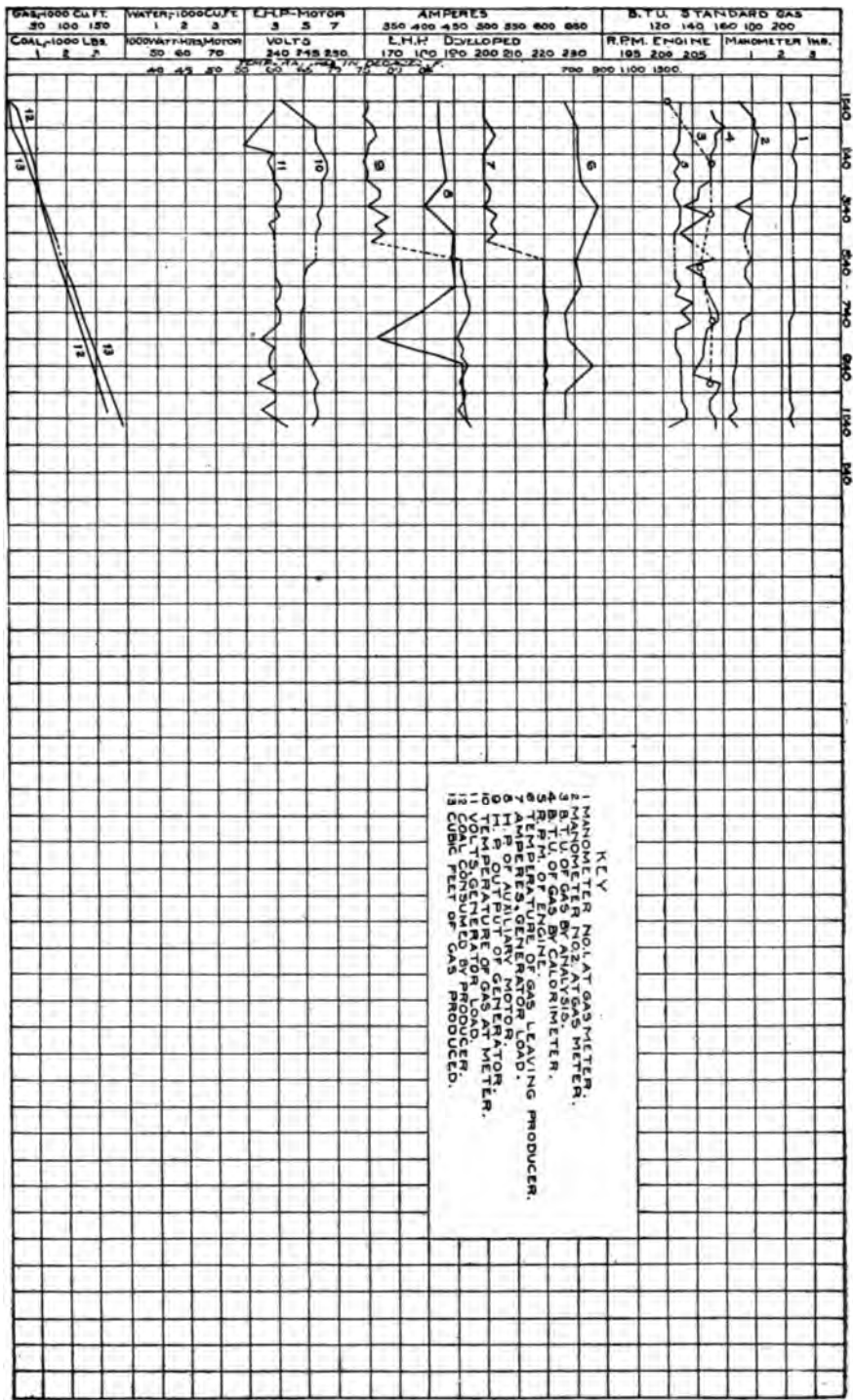


FIG. 131.—Graphic log sheet, producer-gas test, West Virginia No. 9 coal.

OPERATIONS OF THE COAL-TESTING PLANT.

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	14, 195
32. Per pound of dry coal.....	14, 580
33. Per pound of combustible.....	15, 500
34. From coal as fired, per hour.....	3, 465, 000
35. From dry coal, per hour.....	3, 465, 000
36. From combustible, per hour.....	3, 465, 000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	83, 937
38. Per hour.....	15, 750
39. Per pound coal consumed in producer.....	64. 6
40. Per pound dry coal consumed in producer.....	66. 3
41. Per pound combustible consumed in producer.....	70. 4
42. Per pound equivalent coal used by producer plant.....	57. 6
43. Per pound equivalent dry coal used by producer plant.....	59. 3
44. Per pound equivalent combustible used by producer plant.....	63

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	150. 9
46. Per pound dry coal burned in producer.....	10, 000
47. Per hour per brake horsepower.....	12, 000

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	154. 1
49. Electrical horsepower developed at switch board.....	168. 3
50. Brake horsepower available for outside purposes.....	181. 4
51. Brake horsepower developed at engine.....	198

EFFICIENCIES.

52. Of conversion and cleaning gas.....	. 686
53. Of producer plant.....	. 608

PRODUCER-GAS TESTS.

1275

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	1. 58	1. 54	1. 45
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	1. 45	1. 41	1. 33
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	1. 23	1. 20	1. 13
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	1. 35	1. 31	1. 23
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	1. 77	1. 72	1. 62
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	1. 62	1. 58	1. 49
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	1. 51	1. 47	1. 38
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	1. 38	1. 34	1. 26

^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	2. 66	Carbon dioxide (CO ₂).....	10. 47
Volatile matter.....	32. 00	Oxygen (O ₂).....	. 33
Fixed carbon.....	59. 61	Carbon monoxide (CO).....	11. 20
Ash.....	5. 73	Hydrogen (H ₂).....	10. 90
	100. 00	Methane (CH ₄).....	6. 20
		Nitrogen (N ₂).....	60. 90
Sulphur.....	1. 00		100. 00

The West Virginia No. 9 is a rich bituminous coal. It burned well and was easily handled in the producer, yielding a gas of uniformly good quality. It makes a good producer fuel.

From 11.40 a. m. to 5 p. m. (designated as test No. 17A) the load was 500 amperes. At 5.20 p. m. the engine was shut down in order to change the ignition setting, and at 5.40 p. m. the test was resumed, the engine carrying full load (600 amperes). At 12.10 a. m. the engine stopped on account of a ground in the igniter circuit. Test No. 17B includes the portion of the run from 5.40 p. m. to 12 midnight.

One hundred and twenty gallons of black tar were extracted.

(For further information regarding this coal, see producer-gas test No. 21, pp. 1281 et seq.)

OPERATIONS OF THE COAL-TESTING PLANT.

Producer-gas test No. 17B, West Virginia No. 9 coal.

[Recorded by W. C. Weidmann and Kurt Toensfeldt, December 19, 1904.]

1. Duration of test, in hours	6.33
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AVERAGE TEMPERATURE, ° F.

2. Gas leaving producer	698
3-6. (See footnote on p. 1027.)	

OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.

7. Total steam used by producer	pounds..	1,253
8. Steam used by producer per hour	do.	235.5
9. Equivalent in pounds of coal per hour		28.9
10. Equivalent in pounds of dry coal per hour		28.1
11. Equivalent in pounds of combustible per hour		26.5
12. Average horsepower required to drive auxiliary machinery		14.1

COAL CONSUMED IN PRODUCER.

16. Total coal consumed	pounds..	1,900
17. Moisture in coal	per cent..	2.66
18. Total dry coal consumed	pounds..	1,848
19. Refuse from dry coal	per cent..	5.89
20. Total refuse from coal	pounds..	108.9
21. Total combustible consumed	do.	1,739.1

COAL PER HOUR.

22. Coal consumed in producer	pounds..	300
23. Dry coal consumed in producer	do.	292
24. Combustible consumed in producer	do.	274.9
25. Equivalent coal used by producer plant	do.	328.9
26. Equivalent dry coal used by producer plant	do.	320.1
27. Equivalent combustible used by producer plant	do.	301.4

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired	pounds..	7.80
29. Dry coal	do.	7.60
30. Combustible	do.	7.15

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired		14,195
32. Per pound of dry coal		14,580
33. Per pound of combustible		15,500
34. From coal as fired, per hour		4,260,000
35. From dry coal, per hour		4,260,000
36. From combustible, per hour		4,260,000

PRODUCER-GAS TESTS.

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GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	99,781
38. Per hour.....	15,770
39. Per pound coal consumed in producer.....	52.6
40. Per pound dry coal consumed in producer.....	54
41. Per pound combustible consumed in producer.....	57.4
42. Per pound equivalent coal used by producer plant.....	48
43. Per pound equivalent dry coal used by producer plant.....	49.3
44. Per pound equivalent combustible used by producer plant.....	52.3

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	151
46. Per pound dry coal burned in producer.....	8,150
47. Per hour per brake horsepower.....	10,060

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	186.9
49. Electrical horsepower developed at switch board.....	201
50. Brake horsepower available for outside purposes.....	220
51. Brake horsepower developed at engine.....	236.5

EFFICIENCIES.

52. Of conversion and cleaning gas.....	.558
53. Of producer plant.....	.506

COAL PER HORSEPOWER PER HOUR.

	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	1.60	1.56	1.47
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	1.49	1.46	1.37
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	1.36	1.33	1.25
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	1.27	1.24	1.16
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	1.76	1.71	1.61
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	1.64	1.59	1.50
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	1.49	1.46	1.37
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	1.39	1.35	1.27

^a Based on an assumed efficiency of 85 per cent for generator and belt.

AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	2.66	Carbon dioxide (CO ₂).....	10.40
Volatile matter.....	32.00	Oxygen (O ₂).....	.20
Fixed carbon.....	59.61	Carbon monoxide (CO).....	13.70
Ash.....	5.73	Hydrogen (H ₂).....	9.55
	100.00	Methane (CH ₄).....	6.60
		Nitrogen (N ₂).....	59.55
Sulphur.....	1.00		100.00

PRODUCER-GAS TESTS.

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GAS ENGINE.

Following are results of tests on the gas engine:

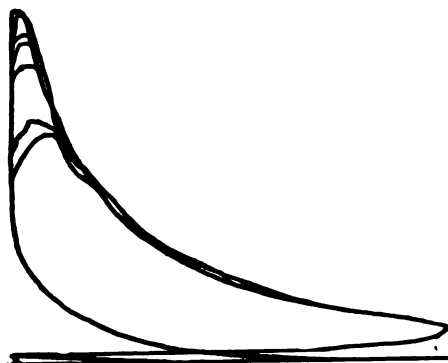
Report of gas-engine test No. 17A.

Recorded by K. Toensfeldt and W. C. Weidmann, December 19, 1904.

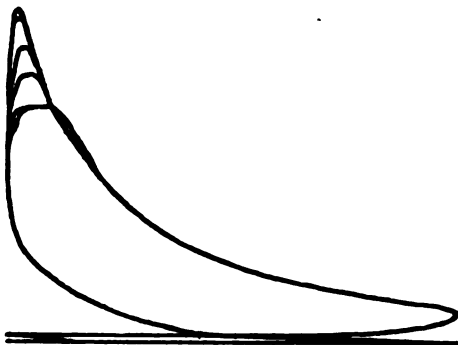
Producer test No. 17A.

Coal: General number, West Virginia No. 9; special number, G. P. 17A. Car initials and number, C. and O. 12932.

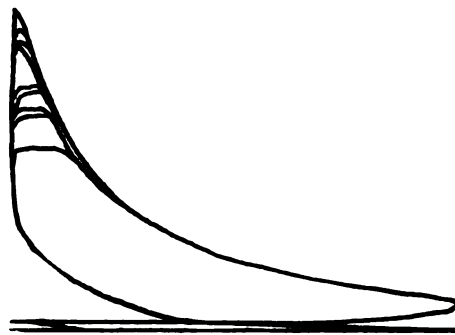
Duration of test, in hours 5½
Revolutions per minute (mean) 202.5



Right cylinder. M. E. P., 66; Max., 220; Rel., 30; I. H. P., 103.4.



Center cylinder. M. E. P., 63; Max., 220; Rel., 30; I. H. P., 100.1.

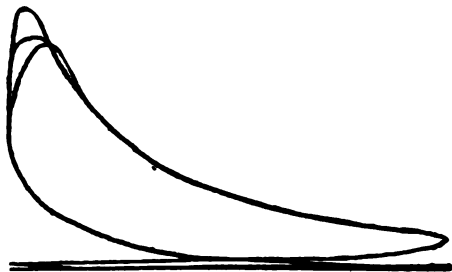


Left cylinder. M. E. P., 53; Max., 210; Rel., 29; I. H. P., 84.3.

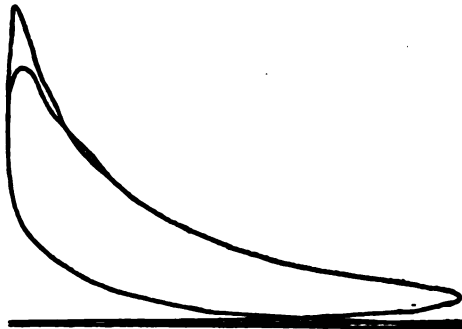
Indicator diagrams taken December 19, 1904, during gas-engine test No. 17A, on West Virginia No 9 coal. Revolutions per minute, 202.

Explosions per minute (mean) 101.25
Cubic feet gas per hour, by meter 15,920
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure) 15,740
Maximum pressure:
First cylinder 210
Second cylinder 220
Third cylinder 220

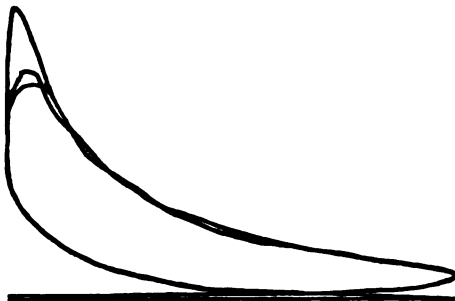
Pressure at release:	
First cylinder.....	25.7
Second cylinder.....	27.3
Third cylinder.....	23.9
Mean effective pressure:	
First cylinder.....	54
Second cylinder.....	56.3
Third cylinder.....	48.3



Right cylinder. M. E. P., 52; Max., 200; Rel., 25; I. H. P., 83.1



Center cylinder. M. E. P., 50; Max., 240; Rel., 28; I. H. P., 94.3



Left cylinder. M. E. P., 50; Max., 220; Rel., 24; I. H. P., 79.8

Indicator diagrams taken December 19, 1904, during gas-engine test No. 17B, on West Virginia No. 9 coal. Revolutions per minute, 202.8.

Indicated horsepower:	
First cylinder.....	86.16
Second cylinder.....	89.9
Third cylinder.....	77.1
Total indicated horsepower.....	253.16
Horsepower delivered (electrical horsepower).....	168.3
Mechanical efficiency (engine and generator combined)..... per cent..	66.4
Cubic feet standard gas per hour per indicated horsepower.....	62.2
Cubic feet standard gas per hour per electrical horsepower.....	93.6

PRODUCER-GAS TESTS.

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Report of gas-engine test No. 17B.

Recorded by K. Toensfeldt and W. C. Weidmann, December 19, 1904.

Producer test No. 17B.

Coal: General number, West Virginia No. 9; special number, G. P. 17B. Car initials and number, C. and O. 12932.

Duration of test, in hours.....	6½
Revolutions per minute (mean).....	203
Explosions per minute (mean).....	101. 5
Cubic feet gas per hour, by meter.....	15, 980
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	15, 760
Maximum pressure:	
First cylinder.....	305
Second cylinder.....	261
Third cylinder.....	212
Pressure at release:	
First cylinder.....	30
Second cylinder.....	30. 5
Third cylinder.....	27. 2
Mean effective pressure:	
First cylinder.....	62. 5
Second cylinder.....	61. 37
Third cylinder.....	52. 75
Indicated horsepower:	
First cylinder.....	99. 8
Second cylinder.....	98. 2
Third cylinder.....	84. 15
Total indicated horsepower.....	282. 15
Horsepower delivered (electrical horsepower).....	201
Mechanical efficiency (engine and generator combined)..... per cent..	71. 2
Cubic feet standard gas per hour per indicated horsepower.....	55. 8
Cubic feet standard gas per hour per electrical horsepower.....	78. 4

GENERAL RESULTS OF ADDITIONAL TEST.

The general results of an additional test of West Virginia No. 9 coal are shown in the following tables:

OPERATIONS OF THE COAL-TESTING PLANT.

Log of producer-gas test No. 21, West Virginia No. 9 coal, January 27, 28, 1905.

[Coal from Vulcan mine of the Mount Carbon Coal Company (Limited), Powellton, W. Va.]

Time.	(Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of Gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).	Auxiliary motors.		Speed counters on gas engine.		Load.	Air entering producer (° C.).		Manometers at producer.		Temperatures.			Gas calorimeter.			B. T. U.		
						Watt meter.		Ammeter.	1.		2.	Volts.	Amperes.	14	15	16	Gas (° F.).	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.
						1.	2.																
1 p. m.	300	572,200	70		2.0	-0.2	37,200		0,000	240	619	650			80	4.5	12.3	870	0.2	151.6		157.0	
1.20 p. m.		579,230	70	36,906	2.1	+			1,921	242	604	600			79	4.5	13.4	820	.2	144.4		149.1	
1.40 p. m.		586,200	70		2.1				3,940	240	614	700			78	4.4	13.4	870	.2	155.1		160.1	
1.45 p. m.	300																						
2 p. m.		592,990	70		2.1	0	39,120		5,954	242	575	620	0.8	8.0	78	4.4	14.4	760	.2	150.8		155.7	
2.20 p. m.		599,720	70		2.2	.5			7,957	238	624	710			75	4.4	13.1	870	.2	149.9		153.7	
2.40 p. m.		606,790	70		2.2	.5			9,967	240	619	700									(b)		
3 p. m.	300	613,450	70		2.2	.4	40,920		11,980	238	639	720			73	4.5	12.9	880	.2	146.4		149.6	
3.20 p. m.		620,310	70	37,224	2.2	1.0			13,992	244	624	560			72	4.5	13.9	830	.2	154.8		158.0	
3.40 p. m.		626,400	70		2.2	1.0			16,017	244	609	590			71	4.5	15.0	760	.2	158.3		161.3	
4 p. m.		632,270	71		2.2	.8	42,820		18,037	235	624	640	.5	4.5	70	4.5	13.6	860	.2	155.1		157.7	
4.20 p. m.		638,280	71		2.3	.8			20,058	237	629	620			70	4.5	14.1	820	.2	155.9		158.5	
4.30 p. m.	300																						
4.40 p. m.		644,170	71		2.4	1.1			22,092	239	609	510			70	4.5	15.5	700	.2	165.1		167.8	
5 p. m.		650,860	70		2.3	1.0	44,700		24,126	238	624	570	.5	5.5	70	4.5	15.2	760	.2	161.1		163.7	
5.20 p. m.		655,570	70	37,550	2.4	1.0			26,154	237	624	580			69	4.5	14.6	810	.2	162.3		164.7	
5.40 p. m.		661,350	70		2.4	.9			28,176	237	634	610			68	4.5	14.0	880	.2	165.9		167.9	
5.45 p. m.	300																						
6 p. m.		667,090	69		2.4	1.2	46,500		30,211	237	624	500	.4	4.5	67	4.4	15.1	770	.2	163.1		164.8	
6.20 p. m.			69		2.4	1.2			32,246	238	619	540			66	4.5	14.8	800	.2	163.5		165.1	
6.40 p. m.		678,110	69		2.4	1.2			34,269	238	619	550			65	4.4	14.0	880	.2	167.4		168.4	
6.50 p. m.	300																						
7 p. m.		683,000	69		2.4	1.2	48,400		36,300	238	624	500	.6	6.0	64	4.4	13.7	920	.2	169.8		170.7	
7.20 p. m.		690,200	69		2.4	1.2			38,320	238	624	550			63	4.4	14.2	800	.2	155.5		156.0	

^a January 27. Average barometer for entire test, 29.81 inches. Producer hopper leaked badly.

^b Calorimeter reading missed on account of interference of workmen.

PRODUCER-GAS TESTS.

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Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Manometers at gas meter (inches water).		Auxiliary motors. Watt meter.		Speed counters on gas engine.		Load. Volts. Amperes.		Temperature of gas leaving producer (° C.).		Manometers at producer. (inches mercury). Gas leaving (inches water).		Temperatures (° C.). Gas. Water. Inlet. Outlet.			Gas calorimeter. Cubic centimeters of water collected.		Cubic feet of gas.		B. T. U. As read. Standardized.	
				1.	2.	1.	2.	1.	2.	11	12	13	14	15	16	17	18	19	20	21	22	23		
7.40 p. m.	300	694,850	69	2.4	1.2					40,340	229	624	500			63	4.4	14.1	830	0.2	159.5	159.9		
7.45 p. m.																								
8 p. m.		700,780	68	2.4	1.1	50,280				42,358	240	620	520			63	4.4	14.6	790	.2	157.9	158.4		
8.20 p. m.		706,500	68	2.4	1.1					44,382	240	624	550			63	4.5	14.5	800	.2	158.7	159.2		
8.40 p. m.	300	712,150	68	2.4	1.1					46,412	241	624	500	0.4	5.0	63	4.4	14.7	790	.2	158.5	160.0		
9 p. m.		717,700	69	2.4	1.2	52,200				48,436	241	624	520			62	4.5	15.0	790	.2	162.2	162.3		
9.20 p. m.		723,150	69	2.4	1.2					50,474	240	614	550			63	4.5	14.8	800	.2	163.5	164.0		
9.40 p. m.	300	728,850	69	2.4	1.1					52,406	239	624	540			64	4.5	14.0	890	.2	161.9	162.7		
10 p. m.		734,550	69	2.4	1.1	54,100				54,327	242	604	500			63	4.5	14.6	820	.2	164.3	164.8		
10.20 p. m.		740,000	69	2.4	1.0					56,559	240	624	560	.5	6.0	62	4.4	14.2	840	.2	159.5	160.7		
10.40 p. m.	300	745,950	69	2.4	1.0					58,585	240	624	560			62	4.4	13.9	850	.2	160.3	160.5		
11 p. m.		751,000	70	2.4	1.0	56,100				60,616	240	624	540			64	4.5	14.8	830	.2	168.4	170.3		
11.20 p. m.		757,250	70	2.4	1.1					63,646	240	614	560			65	4.5	14.9	830	.2	171.0	172.0		
11.40 p. m.	300	762,800	70	2.4	1.0					64,980	238	624	570			64	4.5	15.2	760	.2	161.5	162.3		
12 p. m.		768,000	70	2.4	1.1	58,040				66,709	240	614	520	.4	4.5	65	4.5	15.8	730	.2	163.5	164.5		
12.20 a. m.		774,210	70	2.4	1.1					68,743	240	610	540			65	4.5	16.2	730	.2	168.4	170.5		
12.40 a. m.		779,870	70	2.4	1.1					70,777	238	624	560			66	4.5	16.0	720	.2	164.3	165.5		
1 a. m.	300	785,640	70	2.4	1.0	59,910				72,806	238	620	570			66	4.5	15.6	750	.2	165.0	166.8		
1.20 a. m.		791,380	70	2.4	1.0					74,837	239	614	560			66	4.5	15.7	730	.2	161.9	163.8		
1.40 a. m.		797,150	70	2.4	1.0					76,867	239	614	610			66	4.5	16.0	720	.2	164.3	165.2		
2 a. m.	300	802,950	70	2.4	1.0	61,920				78,895	238	624	600	.5	5.5	66	4.6	15.7	720	.2	158.7	160.2		
2.20 a. m.		808,070	70	2.4	1.1					80,929	239	624	520			66	4.6	16.4	700	.2	163.9	165.3		
2.40 a. m.		814,380	70	2.4	1.1					82,940	240	624	540			66	4.5	16.0	710	.2	161.9	163.4		
3 a. m.	300	820,200	70	2.4	1.0	63,880				84,963	240	624	520			66	4.5	16.0	700	.2	159.5	161.0		
3.20 a. m.		825,750	70	2.4	1.1					87,027	241	609	550			66	4.6	16.4	700	.2	163.9	165.4		

a January 28.

Log of producer-gas test No. 21, West Virginia No. 9 coal, January 27, 28, 1905—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Gas calorimeter.				B. T. U.	
				1.	2.	1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Ampere.	14	15	16	17	18	19	20	21	22	23
3.40 a. m.		831,360	70	2.4	1.1					89,059		241	594	550			65	4.5	15.9	720	0.2	162.7	163.7
4 a. m.		837,190	69	2.4	.8			65,680		91,088		230	614	580			64	4.5	15.2	730	.2	154.8	155.2
4.20 a. m.		843,190	68	2.4	.7					93,109		238	624	600			65	4.5	14.5	750	.2	148.8	149.8
4.30 a. m.	300																						
4.40 a. m.		849,390	69	2.4	1.0					95,130		240	604	540			64	4.5	15.4	700	.2	151.2	151.9
5 a. m.		855,350	68	2.4	1.0			67,610		97,155		242	619	580			64	4.5	15.3	720	.2	154.3	155.1
5.20 a. m.		861,310	68	2.4	1.0					99,195		240	624	610			64	4.5	15.0	720	.2	150.0	150.8
5.30 a. m.	300																						
5.40 a. m.		867,880	68	2.4	1.0					101,201		242	619	580			64	4.5	15.5	710	.2	153.5	154.3
6 a. m.		873,300	68	2.4	1.0			69,520		103,230		242	585	610			64	4.5	15.6	700	.2	153.9	154.8
6.20 a. m.		879,250	68	2.4	1.0					105,255		240	624	630			64	4.5	14.9	740	.2	152.7	153.5
6.40 a. m.		885,300	67	2.4	1.0					107,254		240	624	660			64	4.5	13.2	860	.2	146.4	149.2
6.45 a. m.	300																						
7 a. m.		891,540	67	2.4	1.0			71,560		109,287		240	624	610			64	4.5	16.2	720	.2	167.0	167.8
7.20 a. m.		897,320	67	2.4	1.0					111,316		242	604	640			65	4.5	15.8	730	.2	163.5	164.5
7.40 a. m.		903,300	67	2.4	1.0					113,340		240	624	620			65	4.5	14.7	760	.2	153.9	154.8
8 a. m.	300									115,361		242	629	600			65	4.5	15.0	760	.2	159.9	160.9
8.20 a. m.		915,100	67	2.4	1.0			73,470		117,389		240	629	530			66	4.4	15.4	720	.2	157.1	158.6
8.40 a. m.		920,740	67	2.4	1.0					119,417		242	624				65	4.4	15.8	720	.2	162.7	163.7
9 a. m.		926,000	68	2.4	1.0			75,400		121,442		241	624	550			63	4.4	15.7	720	.2	161.9	162.6
9.20 a. m.		931,650	69	2.4	1.0					123,470		241	624	580			63	4.4	15.4	700	.2	162.8	163.5
9.40 a. m.	300									125,495		242	624	540			62	4.4	14.8	710	.2	146.4	146.6
10 a. m.		943,100	69	2.4	1.0			77,300		127,530		242	624	530			61	4.4	15.6	740	.2	164.3	164.3
10.20 a. m.		948,600	69	2.4	1.0					130,555		240	624	550			61	4.5	15.5	730	.2	155.1	155.1
10.40 a. m.		954,000	69	2.4	1.1					131,575		241	624	550			61	4.4	15.0	750	.2	172.6	172.6

Log of producer-gas test No. 21, West Virginia No. 9 coal, January 27, 28, 1905—Continued.

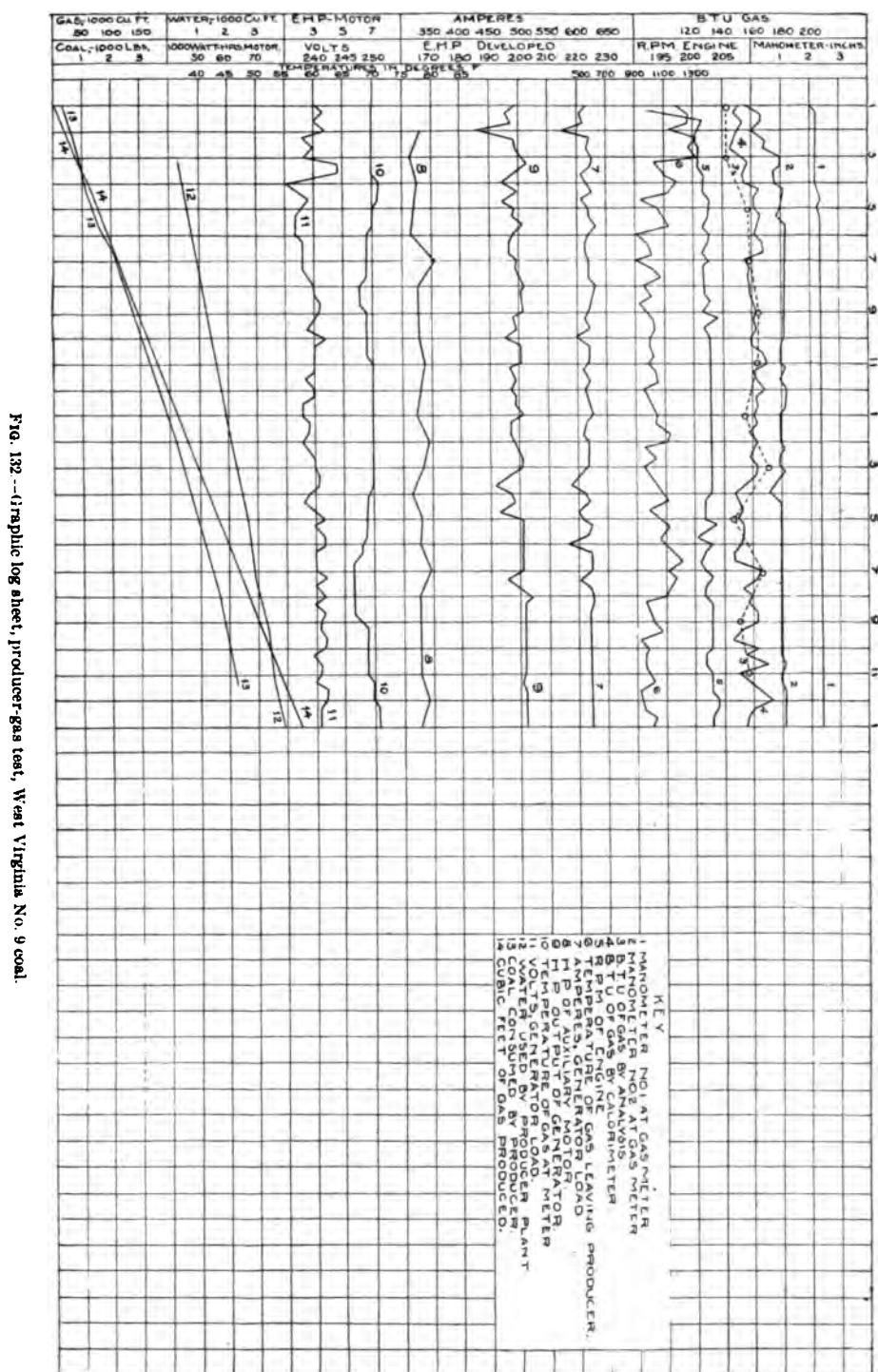
Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).	Manometers at producer.			Temperatures (° C.).			Gas calorimeter.			B. T. U.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
11 a. m.	959,750	60	40,538	2.4	1.0	70,200				133,605	241	624	500	0.4	5.0	61	4.4	14.7	730	0.2	148.8	148.3	148.8	148.8	148.8
11.20 a. m.	965,950	70								135,636	240	624	580			65	4.5	14.0	780	.2	156.7	156.7	157.7	157.7	157.7
11.30 a. m.	300																								
11.40 a. m.	971,450	70			2.4	1.1				137,653	242	624	500			66	4.4	16.1	710	.2	164.7	166.3	166.3	166.3	166.3
12 m.	976,700	70			2.4	1.1	81,200			139,698	242	624	510			65	4.4	16.4	710	.2	173.0	174.0	174.0	174.0	174.0
12.20 p. m.	982,600	71			2.4	1.1				141,733	241	624	510			65	4.4	16.0	700	.2	161.1	162.1	162.1	162.1	162.1
12.40 p. m.	988,250	71			2.4	1.1				143,760	241	624	560			68	4.5	15.9	700	.2	158.3	160.3	160.3	160.3	160.3
1 p. m.	993,900	71			2.4	1.1	83,100			145,790	241	624	550			68	4.6	15.6	720	.2	157.1	159.1	159.1	159.1	159.1

GAS ANALYSES.								
Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
1.10 p. m. <i>a</i>	9.8	0.0	12.6	10.0	5.0	62.6	100.0	142.2
3.10 p. m.	10.6	.4	12.6	9.8	6.1	60.5	100.0	143.0
5.10 p. m.	9.2	.0	16.0	9.3	6.6	58.9	100.0	158.5
7.10 p. m.	9.2	.2	16.0	11.3	6.0	57.3	100.0	159.1
9.10 p. m.	9.0	.2	14.6	11.9	6.7	57.6	100.0	163.7
11.10 p. m.	9.0	.0	14.0	11.0	7.1	58.9	100.0	162.8
1.10 a. m. <i>b</i>	8.8	.4	15.6	10.5	6.0	58.7	100.0	154.9
3.10 a. m.	8.4	.4	16.8	8.7	7.7	58.0	100.0	170.9
5.10 a. m.	9.0	.4	14.6	9.4	6.1	60.5	100.0	148.6
7.10 a. m.	8.4	.0	14.8	8.3	8.0	60.5	100.0	165.7
9.10 a. m.	8.4	1.4	15.8	9.5	5.7	59.2	100.0	148.9
11.10 a. m.	7.0	.6	13.8	4.4	8.8	65.4	100.0	156.2
<i>a</i> January 27. <i>b</i> January 28.								

Producer-gas test No. 21, West Virginia No. 9 coal.

[Recorded by W. C. Weidmann and Kurt Toensfeldt, January 27, 28, 1905.]

1. Duration of test, in hours.....	24
AVERAGE TEMPERATURE, ° F.	
2. Gas leaving producer.....	1,064
3-6. (See footnote on p. 1027.)	
OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
7. Total steam used by producer..... pounds..	6,795
8. Steam used by producer per hour.....do....	283
9. Equivalent in pounds of coal per hour.....	34.8
10. Equivalent in pounds of dry coal per hour.....	34
11. Equivalent in pounds of combustible per hour.....	31.6
12. Average horsepower required to drive auxiliary machinery.....	10.3
13. Total water used in scrubber and tar extractor..... cubic feet..	3,967
14. Cubic feet of water per hour per horsepower of producer plant.....	.661
15. Cubic feet of water per 1,000 cubic feet of gas produced.....	9.55
COAL CONSUMED IN PRODUCER.	
16. Total coal consumed..... pounds..	6,000
17. Moisture in coal.....per cent..	2.22
18. Total dry coal consumed..... pounds..	5,867
19. Refuse from dry coal.....per cent..	7.06
20. Total refuse from coal..... pounds..	414
21. Total combustible consumed.....do....	5,453



OPERATIONS OF THE COAL-TESTING PLANT.

COAL PER HOUR.

22. Coal consumed in producer.....	pounds..	250
23. Dry coal consumed in producer.....	do....	244.5
24. Combustible consumed in producer.....	do....	227
25. Equivalent coal used by producer plant.....	do....	224.8
26. Equivalent dry coal used by producer plant.....	do....	278.5
27. Equivalent combustible used by producer plant.....	do....	258.6

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired.....	pounds..	6.50
29. Dry coal.....	do....	6.36
30. Combustible.....	do....	5.90

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	14,224
32. Per pound of dry coal.....	14,548
33. Per pound of combustible.....	15,650
34. From coal as fired, per hour.....	3,555,000
35. From dry coal, per hour.....	3,555,000
36. From combustible, per hour.....	3,555,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	415,660
38. Per hour.....	17,330
39. Per pound coal consumed in producer.....	69.3
40. Per pound dry coal consumed in producer.....	70.9
41. Per pound combustible consumed in producer.....	76.3
42. Per pound equivalent coal used by producer plant.....	60.9
43. Per pound equivalent dry coal used by producer plant.....	62.2
44. Per pound equivalent combustible used by producer plant.....	67

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	160.5
46. Per pound dry coal burned in producer.....	11,380
47. Per hour per brake horsepower.....	11,860

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	189
49. Electrical horsepower developed at switch board.....	199.3
50. Brake horsepower available for outside purposes.....	222.4
51. Brake horsepower developed at engine.....	234.4

EFFICIENCIES.

52. Of conversion and cleaning gas.....	.782
53. Of producer plant.....	.682

PRODUCER-GAS TESTS.

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COAL PER HORSEPOWER PER HOUR.

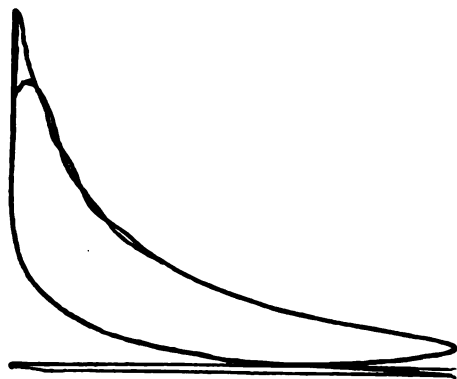
	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	1.32	1.29	1.20
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	1.26	1.23	1.14
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	1.18	1.10	1.02
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	1.07	1.04	.97
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	1.51	1.47	1.37
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	1.43	1.40	1.30
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	1.28	1.25	1.16
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	1.21	1.19	1.10

^a Based on an assumed efficiency of 85 per cent for generator and belt.

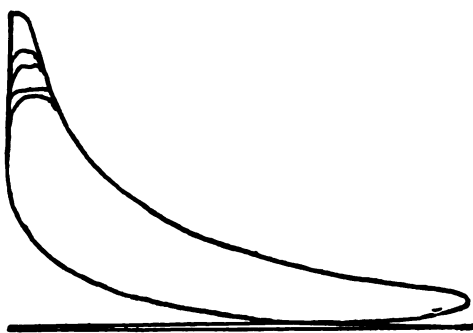
AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	2.22	Carbon dioxide (CO ₂).....	8.90
Volatile matter.....	31.05	Oxygen (O ₂).....	.33
Fixed carbon.....	59.83	Carbon monoxide (CO).....	14.77
Ash.....	6.90	Hydrogen (H ₂).....	9.52
	100.00	Methane (CH ₄).....	6.65
Sulphur.....	.79	Nitrogen (N ₂).....	59.83
			100.00

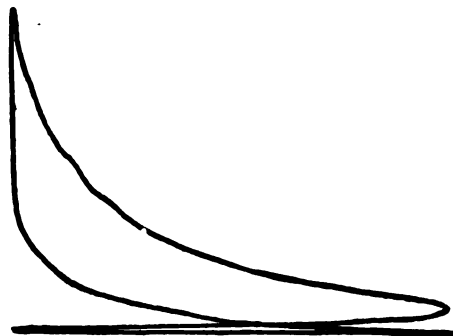
Test No. 17 was on this same coal, but the run was so short it was deemed wise to make another test.



Right cylinder. M. E. P., 56; Max., 300; Rel., 23; I. H. P., 92.2



Center cylinder. M. E. P., 61; Max., 240; Rel., 25; I. H. P., 97.



Left cylinder. M. E. P., 48; Max., 270; Rel., 22; I. H. P., 76.3

Indicator diagrams taken January 27, 1905, during gas-engine test No. 21, on West Virginia No. 9 coal. Revolutions per minute. 201.8.

This test confirmed the good opinion of this coal as a gas producer, obtained in the previous test.

Fifty gallons of black tar were extracted during the run.

PRODUCER-GAS TESTS.

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ADDITIONAL GAS-ENGINE TEST.

Following are results of additional test on the gas engine:

Report of gas-engine test No. 21.

Recorded by K. Toensfeldt and W. C. Weidmann, January 27, 28, 1905.

Producer test No. 21.

Coal: General number, West Virginia No. 9; special number, G. P., 21. Car initials and number, C. and O 12932.

Duration of test, in hours.....	24
Revolutions per minute (mean).....	202.5
Explosions per minute (mean).....	101.25
Cubic feet gas per hour, by meter.....	17,570
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	17,320
Maximum pressure:	
First cylinder.....	255
Second cylinder.....	235
Third cylinder.....	255
Pressure at release:	
First cylinder.....	27
Second cylinder.....	25
Third cylinder.....	23
Mean effective pressure:	
First cylinder.....	59.75
Second cylinder.....	61
Third cylinder.....	49.75
Indicated horsepower:	
First cylinder.....	94.98
Second cylinder.....	96.95
Third cylinder.....	79.08
Total indicated horsepower.....	271.01
Horsepower delivered (electrical horsepower).....	199.3
Mechanical efficiency (engine and generator combined)..... per cent..	73.5
Cubic feet standard gas per hour per indicated horsepower.....	63.9
Cubic feet standard gas per hour per electrical horsepower.....	86.9

WEST VIRGINIA No. 12.

GENERAL RESULTS.

The general results of tests of West Virginia No. 12 coal are tabulated as follows:

Log of producer-gas test No. 8, West Virginia No. 12 coal, November 7, 8, 1904.
[Coal from mine of the Big Sandy Coal and Coke Company, Big Sandy, W. Va.]

Time.	Total consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.				Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.			Temperatures (° C.).				Cubic feet of gas.		B. T. U.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
				1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	13	14	15	16	17	18	19	20	21	22	23	24	25	26																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
1	9.20 a. m.	4,053,430	57.5	68,630	1.9	-0.2	183,870	22.0	22,836	62,836	240	630	420																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			

a November 7, 9.20 a. m. to 7 p. m., barometer 29.45 inches; 7 p. m. to 7 a. m. November 8, barometer 29.49 inches.

PRODUCER-GAS TESTS.

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Log of producer-gas test No. 8, West Virginia No. 12 coal, November 7, 8, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).	Auxiliary motors.			Speed counters on gas engine.			Load.		Temperature of gas leaving producer (° C.).	Manometers at pro- ducer.			Temperatures (° C.).				Gas calorimeter.				B. T. U.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
						Watt meter.	Ammeter.	1. 2.		1.	2.	Volts.	Amperes.		Air entering (inches mer- cury).	Gas leaving wa- ter.	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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12.40 p. m.		4,125,170	68.0		1.7 -0.3				27.5	43,050			241	634	500	0.65	7.0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										</

Log of producer-gas test No. 8, West Virginia No. 12 coal, November 7, 8, 1904—Continued.

Time.	Coal consumed by producer (pounds).					Gas meter (cubic feet).		Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Manometers at producer.		Temperatures (° C.).			Gas calorimeter.		B. T. U.
	1	2	3	4	5	Gas meter (cubic feet).	Water meter (cubic feet).	Manometers at gas meter (inches water).	Auxiliary motors.	Speed counters on gas engine.	Load.	Manometers at producer.	Temperatures (° C.).	Gas.	Water.	Outlet.	Cubic centimeters of water collected.	Cubic feet of gas.	As read.	Standardized.							
4.50 p. m.	300	4,213,250	67.5	2.8	0.8	23.0	69,572	241	614	400	20.0	13.1	22.00	770	0.2	133.7	137.5										
5 p. m.	300	4,213,250	67.5	2.8	0.8	23.0	69,572	241	614	400	20.0	13.1	22.00	770	0.2	133.7	137.5										
5.10 p. m.	300	4,213,250	67.5	2.8	0.8	23.0	69,572	241	614	400	20.0	13.1	22.00	770	0.2	133.7	137.5										
5.20 p. m.	300	4,219,620	67.0	2.7	.7	23.0	71,611	242	614	480	20.0	13.0	20.56	970	.2	145.4	149.3										
5.25 p. m.	300	4,225,940	66.0	2.8	.7	24.5	73,655	242	619	440	0.6	7.0	18.0	13.0	20.50	940	.2	138.8	142.0								
5.30 p. m.	300	4,232,250	65.0	2.7	.9	22.0	75,702	241	619	480	17.5	13.0	21.32	870	.2	143.2	146.2										
5.40 p. m.	300	4,238,500	65.0	2.6	.7	25.0	77,741	240	619	450	17.0	13.0	20.40	950	.2	143.2	145.8										
5.50 p. m.	300	4,244,660	65.0	2.5	.6	20.0	79,784	241	619	500	.55	5.5	19.0	13.0	21.30	850	.2	130.7	143.4								
6 p. m.	300	4,250,750	65.0	2.4	.8	24.0	81,827	240	624	430	19.0	13.0	20.85	950	.2	149.6	153.6										
6.13 p. m.	300	4,256,910	65.0	2.2	.7	24.0	83,869	241	619	440	19.0	13.0	20.59	950	.2	142.8	144.8										
6.20 p. m.	300	4,263,200	65.0	2.2	.5	17.5	85,907	238	619	450	.6	6.0	18.5	13.0	20.11	980	.2	137.7	140.7								
6.25 p. m.	300	4,269,490	65.0	2.2	.6	25.0	87,941	241	629	490	20.0	13.2	19.90	1,000	.2	132.9	136.7										
6.30 p. m.	300	4,275,350	65.0	2.5	.5	25.0	89,988	240	619	440	.6	7.0	19.0	13.2	21.84	870	.2	148.8	152.4								
6.35 p. m.	300	4,281,640	65.0	2.5	.5	25.0	92,035	240	619	440	.6	7.0	16.0	13.0	21.05	940	.2	140.0	141.8								

Log of producer-gas test No. 8, West Virginia No. 12 coal, November 7, 8, 1904—Continued.

Time.	Coal consumed by producer (pounds).			Temperature of gas (° F.).			Manometers at gas meter (inches water).		Auxiliary motors. Speed counters on gas engine.			Load.		Temperature of gas leaving producer (° C.).			Manometers at producer. (Inches water).			Gas calorimeter.				B. T. U.		
																				Temperatures (° C.).		Cubic feet of gas.	As read.		Standardized.	
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.					22.	23.
8.40 p. m.			4,281,360	64.5		2.2	0.6		25.0	92,031		238	619	448				17.5	13.0	21.18	900	0.2	146.0	148.6		
8.55 p. m.			4,287,380	64.0		2.3	.7		20.0	94,072		238	614	460												
9 p. m.																										
9.15 p. m.		300																								
9.20 p. m.			4,293,650	64.0	69,704	2.3	.6		25.0	96,069		240	619	460	0.6	6.0		16.5	13.2	19.81	1,060	.2	138.8	140.8		
9.25 p. m.								202,250																		
9.35 p. m.			4,299,900	64.0		2.3	.8		24.0	98,129		242	619	460				15.0	13.0	19.17	1,300	.2	147.8	149.0		
9.55 p. m.																										
10 p. m.			4,305,950	64.0		2.3	.8		27.0	166		240	619	460				15.5	13.1	20.62	980	.2	146.0	146.2		
10.20 p. m.			4,311,950	63.5		2.3	.7		26.0	2,200		240	614	480				14.5	13.0	20.00	1,000	.2	138.8	139.8		
10.25 p. m.								203,940																		
10.30 p. m.		300																								
10.40 p. m.			4,318,160	64.0		2.2	.6		27.5	4,241		240	614	480	.7	7.5		14.0	13.0	19.90	1,050	.2	143.6	144.3		
11 p. m.			4,324,150	64.0		2.3	.8		18.0	6,277		240	619	480				13.5	13.5	20.80	1,000	.2	144.9	145.3		
11.20 p. m.			4,330,250	63.0	70,032	2.2	.5		20.0	8,322		238	619	500				18.5	13.3	19.97	1,050	.2	139.3	142.3		
11.25 p. m.								205,410																		
11.30 p. m.		300																								
11.40 p. m.			4,336,500	63.0		2.2	.6		30.0	10,359		240	619	480				18.0	13.4	20.91	1,000	.2	148.8	151.9		
12 p. m.			4,342,500	62.5		2.3	.7		27.0	12,386		240	619	440	.6	6.5		18.0	13.4	21.66	900	.2	148.0	151.1		
12.20 a. m.			4,348,300	62.0		2.4	.9		22.0	14,439		240	619	480				18.0	13.4	21.82	950	.2	158.3	161.6		
12.25 a. m.								207,100																		
12.40 a. m.			4,354,320	62.0		2.2	.7		30.0	16,483		240	619	480				18.0	13.4	20.45	1,050	.2	146.8	149.8		
1 a. m.			4,360,525	62.0		2.0	.2		22.0	18,516		236	614	480	.6	7.0		18.0	13.4	18.85	1,300	.2	140.5	143.3		
1.20 a. m.			4,367,000	61.5	70,280	2.1	.3		22.0	20,542		240	619	480				18.0	13.4	18.67	1,300	.2	138.5	141.3		

^a November 8; 7 a. m. to end of test, barometer 29.45 inches.

PRODUCER-GAS TESTS.

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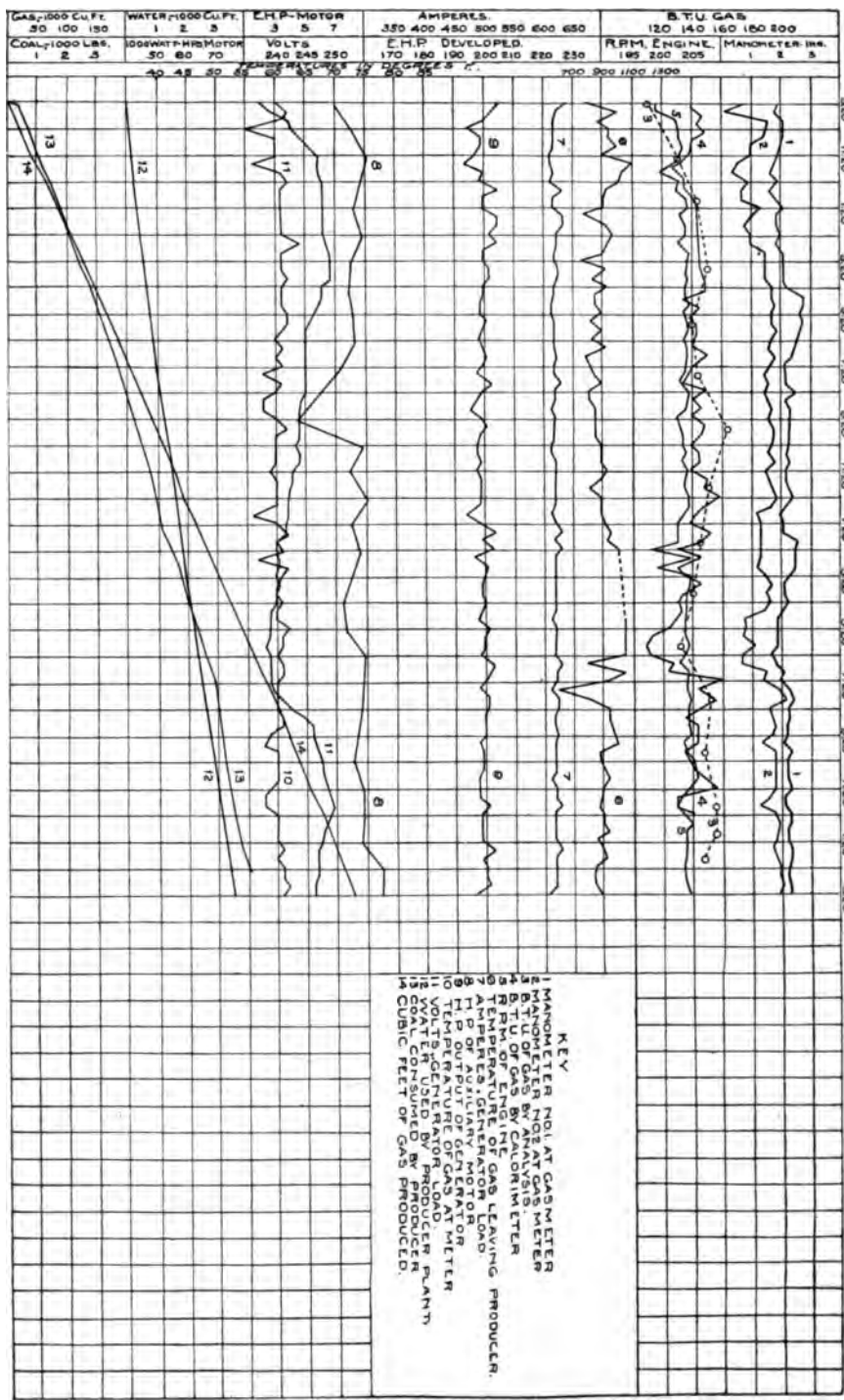
Log of producer-gas test No. 8, West Virginia No. 12 coal, November 7, 8, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of gas (° F.).		Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometer at producer.			Temperatures (° C.).				Gas calorimeter.				B. T. U.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Standardized.							
6.40 a. m.		4,472,800	59.0		1.8	-0.3		26.0	53,057		241	629	420			11.0	14.0	18.40	1,450	0.2	126.6	127.2	127.2							
7 a. m.		4,479,580	59.0		2.1	+.5		22.0	55,102		241	624	540			11.5	15.2	20.80	1,200	.2	123.3	122.8	122.8							
7.15 a. m.	300																													
7.20 a. m.		4,486,000	59.0	71,038	2.0	.4		28.0	57,146		240	624	500			12.0	13.0	18.30	1,500	.2	160.7	160.7	160.7							
7.40 a. m.		4,492,240	59.5		2.3	.9		27.0	59,188		240	614		0.5	7.0	13.0	12.9	18.90	1,200	.2	142.9	143.3	143.3							
8 a. m.		4,498,000	61.0		2.4	1.2		22.0	61,234		240	624	450			13.0	13.0	19.20	1,250	.2	153.9	154.4	154.4							
8.20 a. m.		4,504,150	62.0		2.2	.6		24.0	63,277		240	624	310			20.0	13.0	18.40	1,350	.2	144.9	146.7	146.7							
8.25 a. m.							219,460																							
8.40 a. m.		4,510,200	64.0		2.3	.7		22.0	65,321		241	619	500			18.0	14.6	23.42	1,150	.2	133.7	136.5	136.5							
9 a. m.		4,516,150	66.0		2.2	.8		22.5	67,365		241	619	500			18.5	13.4	21.90	850	.2	143.3	143.8	143.8							
9.20 a. m.		4,522,250	66.0	71,331	2.2	.7		22.5	69,411		239	624	510			20.0	13.4	21.00	950	.2	143.3	143.8	143.8							
9.40 a. m.		4,528,450	66.5		2.1	.3		22.0	(a)	11,444	238	619	520	.6	6.0	21.0	13.5	20.30	1,050	.2	141.6	146.0	146.0							
10 a. m.	300	4,534,960	67.0		2.3	.8		28.0		13,463	240	619	530			23.0	13.6	21.13	900	.2	134.1	138.3	138.3							
10.20 a. m.		4,541,200	67.5		2.2	.8		26.0		15,533	240	619	465			25.0	13.6	23.23	1,100	.2	136.7	146.0	146.0							
10.25 a. m.							222,600																							
10.40 a. m.		4,547,280	67.5		2.2	.8		27.0		17,584	240	619	470	.55	6.0															
11 a. m.		4,553,360	68.0		2.2	.8		22.5		19,640	240	614	485			26.0	13.5	21.37	1,000	.2	156.7	164.3	164.3							
11.20 a. m.		4,559,400	68.5	71,599	2.3	.8		22.0		21,686	239	619	500																	
11.25 a. m.							225,250																							
11.40 a. m.		4,565,600	69.0		2.1	.6		21.0		23,718	238	619	480			26.0	13.7	22.29	750	.2	128.2	134.3	134.3							
12 m.	300	4,571,900	69.5		2.1	.3		28.0		25,739	238	629		.5	6.0	26.0	13.6	22.22	750	.2	128.2	134.3	134.3							
12.20 p. m.		4,578,000	69.0		2.3	.8		26.0		27,773	240	619	465			26.0	13.6	24.40	650	.2	139.3	146.0	146.0							
12.25 p. m.							225,900																							
12.40 p. m.		4,584,080	68.5		2.3	.9		26.0		29,821	240	619	485											(b)						
1 p. m.		4,590,000	68.0		2.2	.9		22.5		31,860	240	619	490																	

^a Speed counter No. 1 out of order.

^b Meter connected to calorimeter out of order.

FIG. 133.—Graphic log sheet, producer-gas test, West Virginia No. 12 coal.



GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
9.23 a. m.	7.6	0.0	14.2	3.4	4.5	70.3	100.0	111.3
11.25 a. m.	10.4	.0	11.6	14.4	3.7	59.9	100.0	130.0
1.05 p. m.	10.2	.2	14.0	14.5	4.2	56.9	100.0	144.1
3.43 p. m.	11.0	.4	14.4	13.9	4.8	55.5	100.0	149.7
5.45 p. m.	10.6	.2	14.8	8.9	5.3	60.2	100.0	140.1
7.45 p. m.	10.4	.0	15.2	13.3	4.2	56.9	100.0	144.1
9.45 p. m.	10.0	.2	16.0	13.4	5.7	54.7	100.0	163.17
12 m.	10.4	.0	13.8	12.8	5.5	57.5	100.0	151.28
2 a. m.	11.4	.0	13.8	13.2	4.8	56.8	100.0	145.22
4 a. m.	11.2	.4	14.0	13.2	4.2	57.0	100.0	139.53
6 a. m.	12.0	.4	12.8	11.9	4.2	58.7	100.0	130.81
8 a. m.	10.2	.0	13.6	17.0	4.3	54.9	100.0	152.22
10 a. m.	9.6	.0	13.6	13.5	4.9	58.4	100.0	146.9
12 m.	10.0	.0	15.0	17.3	4.0	53.7	100.0	155.1
1 p. m.	10.0	.2	14.8	13.2	5.4	56.4	100.0	155.1
2 p. m.	10.4	.0	15.6	13.9	4.1	56.0	100.0	146.48

Producer-gas test No. 8, a West Virginia No. 12 coal.

[Recorded by M. H. Mount and R. E. Peshak, November 7, 8, 1904.]

1. Duration of test, in hours	30
AVERAGE TEMPERATURE, °F.	
2. Gas leaving producer	898
3-6. (See footnote on p. 1027.)	
OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
7. Total steam used by producer	8,550 pounds.
8. Steam used by producer per hour	285 do.
9. Equivalent in pounds of coal per hour	34.9
10. Equivalent in pounds of dry coal per hour	34.4
11. Equivalent in pounds of combustible per hour	32.2
12. Average horsepower required to drive auxiliary machinery	8.5
13. Total water used in scrubber and tar extractor	3,505 cubic feet.
14. Cubic feet of water per hour per horsepower of producer plant	.47
15. Cubic feet of water per 1,000 cubic feet of gas produced	6.16
COAL CONSUMED IN PRODUCER.	
16. Total coal consumed	8,100 pounds.
17. Moisture in coal	1.43 per cent.
18. Total dry coal consumed	7,984 pounds.
19. Refuse from dry coal	6.54 per cent.
20. Total refuse from coal	522 pounds.
21. Total combustible consumed	7,462 do.

* Gas-producer hopper leaked.

PRODUCER-GAS TESTS.

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COAL PER HOUR.

22. Coal consumed in producer.....	pounds..	270
23. Dry coal consumed in producer.....	do.....	266.1
24. Combustible consumed in producer.....	do.....	248.7
25. Equivalent coal used by producer plant.....	do.....	304.9
26. Equivalent dry coal used by producer plant.....	do.....	300.5
27. Equivalent combustible used by producer plant.....	do.....	280.9

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired	pounds..	7.01
29. Dry coal	do.....	6.92
30. Combustible	do.....	6.47

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	14,614
32. Per pound of dry coal.....	14,825
33. Per pound of combustible.....	15,860
34. From coal as fired, per hour.....	3,945,000
35. From dry coal, per hour.....	3,945,000
36. From combustible, per hour.....	3,945,000

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	568,700
38. Per hour.....	18.957
39. Per pound coal consumed in producer.....	70.2
40. Per pound dry coal consumed in producer.....	71.2
41. Per pound combustible consumed in producer.....	76.2
42. Per pound equivalent coal used by producer plant.....	62.1
43. Per pound equivalent dry coal used by producer plant.....	63.2
44. Per pound equivalent combustible used by producer plant.....	67.5

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	142.5
46. Per pound dry coal burned in producer.....	10,150
47. Per hour per brake horsepower.....	11,500

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	191.3
49. Electrical horsepower developed at switch board.....	199.8
50. Brake horsepower available for outside purposes.....	225
51. Brake horsepower developed at engine.....	235

EFFICIENCIES.

52. Of conversion and cleaning gas.....	.685
53. Of producer plant.....	.604

COAL PER HORSEPOWER PER HOUR.

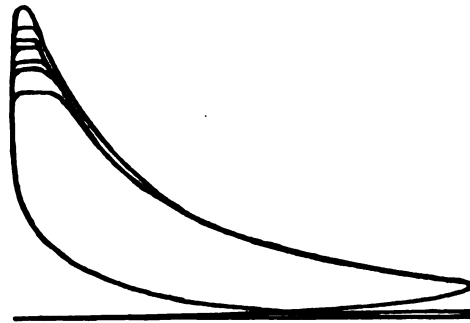
	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	1. 41	1. 39	1. 30
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	1. 35	1. 33	1. 24
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	1. 20	1. 18	1. 11
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	1. 15	1. 13	1. 06
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	1. 59	1. 57	1. 47
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	1. 53	1. 50	1. 40
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	1. 35	1. 34	1. 25
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	1. 30	1. 28	1. 20

^a Based on an assumed efficiency of 85 per cent for generator and belt.

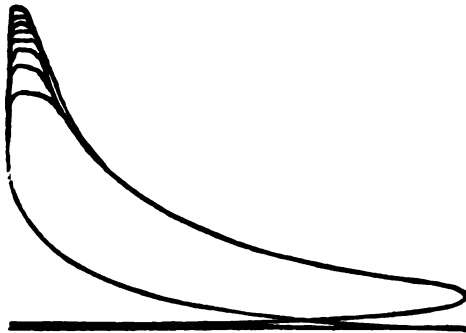
AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	1. 43	Carbon dioxide (CO ₂).....	10. 34
Volatile matter.....	18. 93	Oxygen (O ₂).....	12
Fixed carbon.....	73. 19	Carbon monoxide (CO).....	14. 21
Ash.....	6. 45	Hydrogen (H ₂).....	12. 98
	100. 00	Methane (CH ₄).....	4. 61
Sulphur.....	. 95	Nitrogen (N ₂).....	57. 74
			100. 00

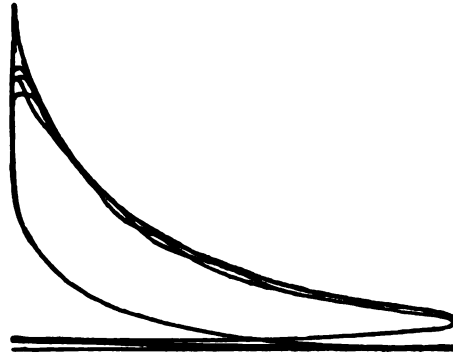
The West Virginia No. 12 coal is of good quality and the bed was easily handled. It is soft and friable, and in going through the rolls much of it was



Right cylinder. M. E. P., 61; Max., 250; Rel., 30; I. H. P., 96.7.



Center cylinder. M. E. P., 58.5; Max., 258; Rel., 36; I. H. P., 93.8.



Left cylinder. M. E. P., 49; Max., 270; Rel., 33; I. H. P., 78.5.

Indicator diagrams taken November 8, 1904, during gas-engine test No. 8, on West Virginia No. 12 coal. Scale of spring, 80; revolutions per minute, 203.3.

reduced to a fine powder which gave trouble in the scrubber and wash box. It yielded about 50 gallons of tar. It may be considered a good gas-producer coal.

GAS ENGINE.

Following are results of tests on the gas engine:

Report of gas-engine test No. 8.

Recorded by R. W. Cummings and W. C. Weidmann, November 7, 8, 1904.	
Producer test No. 8.	
Coal: General number, West Virginia No. 12; special number, G. P. 8. Car initials and number H. V. 24689.	
Duration of test, in hours.....	30
Revolutions per minute (mean).....	203. 7
Explosions per minute (mean).....	101. 8
Cubic feet gas per hour, by meter.....	19,278
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	18,947
Maximum pressure:	
First cylinder.....	260. 4
Second cylinder.....	283. 86
Third cylinder.....	233. 86
Pressure at release:	
First cylinder.....	27. 73
Second cylinder.....	32. 26
Third cylinder.....	28. 90
Mean effective pressure:	
First cylinder.....	59. 8
Second cylinder.....	57. 76
Third cylinder.....	50. 06
Indicated horsepower:	
First cylinder.....	95. 84
Second cylinder.....	92. 66
Third cylinder.....	80. 44
Total indicated horsepower.....	268. 94
Horsepower delivered (electrical horsepower).....	199. 8
Mechanical efficiency (engine and generator combined).....per cent..	74. 4
Cubic feet standard gas per hour per indicated horsepower.....	70. 5
Cubic feet standard gas per hour per electrical horsepower.....	94. 9

WYOMING No. 2.

GENERAL RESULTS.

The general results of tests of Wyoming No. 2 coal are tabulated as follows:

Log of producer-gas test No. 16, Wyoming No. 2 coal, December 16, 17, 1904.
[Coal from Antelope Nos. 1 and 2 and Jumbo mines of the Cambria Fuel Company, Cambria, Wyo.]

Time.	(Coal consumed by producer (pounds).	Gas meter (cubic feet).	Temperature of gas (° F.).	Water meter (cubic feet).	Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.		Temperature of gas leaving producer (° C.).		Manometers at producer.		Temperatures (° C.).				Gas calorimeter.		B. T. U.	
					1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.	12	13	14	15	16	17	18	19	20	21	22	23
10 a. m. a.	300	8,170,560	67.0	142,337	2.0	0.6	665,250					240	624	250	0.7	5.0		9.8	4.9	13.00	900	0.2	144.4	143.0
10.20 a. m.		8,176,400	74.0	(6)	2.3	1.0						240	624	250				10.	5.0	13.70	960	.2	162.6	161.0
10.40 a. m.		8,181,800	78.0		2.3	1.0						240	624											
10.45 a. m.	300																							
11 a. m.		8,186,920	80.0		2.4	1.2	697,530					238	634	240	.35	4.5	10.3	5.1	13.81	870	.2	150.0	148.6	
11.20 a. m.		8,191,880	80.0		2.5	1.5						239	624				10.5	5.0	14.20	900	.2	164.3	162.8	
11.30 a. m.	300																							
11.40 a. m.		8,196,600	80.5		2.5	1.3						240	634				10.5	5.0	13.60	900	.2	144.4	143.3	
12 m.		8,201,550	80.5		2.5	1.3	700,100					240	634	340	.6	5.0	10.5	5.0	12.70	870	.2	133.0	132.0	
12.15 p. m.	300																							
12.20 p. m.		8,206,730	81.0		2.4	1.2						238	634				10.8	5.0	12.10	880	.2	123.4	122.5	
12.40 p. m.		8,211,900	81.5		2.4	1.2						240	624											
1 p. m.	300	8,217,100	79.0		2.5	1.2	702,900					240	624	300	.5	4.0								
1.20 p. m.		8,222,230	79.0		2.5	1.2						240	629				14.5	5.0	14.35	840	.2	153.6	154.4	
1.40 p. m.		8,227,140	78.0		2.5	1.4						240	629				14.5	5.0	14.70	840	.2	161.2	161.9	
1.45 p. m.	300																							
2 p. m.		8,232,090	79.0		2.5	1.4	705,570					241	614	300	.4	5.0	14.5	5.2	14.20	890	.2	153.6	154.4	
2.20 p. m.		8,237,000	78.0		2.5	1.5						240	634				15.0	5.2	14.70	860	.2	161.2	162.2	
2.30 p. m.	300																							
2.40 p. m.		8,241,920	78.0		2.5	1.4						240	634				14.5	5.2	14.00	870	.2	151.6	152.3	
3 p. m.		8,246,930	77.0		2.5	1.5	708,460					240	629	290	.4	5.0	15.0	5.3	14.90	820	.2	156.0	157.0	
3.15 p. m.	300																							
3.20 p. m.		8,251,800	77.0		2.5	1.4						240	624				15.5	5.2	14.20	860	.2	151.2	152.5	
3.40 p. m.		8,256,700	78.0		2.5	1.5						240	644				15.3	5.2	14.58	850	.2	162.7	153.9	

^a December 16. Average barometer for entire test, 29.42 inches.

^b Water meter not in use.

PRODUCER-GAS TESTS.

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Log of producer-gas test No. 16, Wyoming No. 2 coal, December 16, 17, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Gas meter (cubic feet).		Temperature of gas (° F.).	Water meter (cubic feet).		Manometers at gas meter (inches water).		Auxiliary motors.		Speed counters on gas engine.		Load.	Temperature of gas leaving producer (° C.).		Manometers at producer (inches water).		Temperatures (° C.).				Gas calorimeter.		H. T. U.
		Gas meter (cubic feet).	Water meter (cubic feet).		1.	2.	Watt meter.	Ammeter.	1.	2.	Volts.	Amperes.		Air entering (inches mercury).	Gas leaving (inches water).	Gas.	Inlet.	Outlet.	Cubic centimeters of water collected.	(Cubic feet of gas.	As read.	Standardized.		
1		3	4	5	6	7	8	9			10	11	12	13	14	15	16	17	18	19	20	21	22	23
4 p. m. a.	300	8,261,400	77.0		2.5	1.5	711,360			36,521	240	624	280					15.0	5.20	14.30	830	0.2	149.6	150.6
4.20 p. m.		8,266,330	78.0		2.5	1.4				38,553	240	624						16.0	5.00	14.00	900	.2	155.1	156.8
4.40 p. m.		8,271,300	78.0		2.5	1.3				40,592	241	624			0.5	5.0	16.0	5.00	13.90	840	.2	147.4	148.0	
4.45 p. m.	300																							
5 p. m.		8,276,330	78.0		2.5	1.2	714,360			42,630	242	624	300					16.0	5.00	13.70	830	.2	141.3	142.9
5.20 p. m.		8,281,400	78.0		2.5	1.2				44,668	240	624						16.3	5.20	14.30	820	.2	147.5	148.0
5.30 p. m.	300																							
5.40 p. m.		8,286,580	78.0		2.5	1.2				46,700	240	624						16.0	5.10	14.10	820	.2	146.4	148.0
6 p. m.		8,291,710	78.0		2.5	1.2	717,480			48,733	241	624	320		.5	4.5	16.0	5.00	14.40	830	.2	154.7	156.4	
6.15 p. m.	300																							
6.20 p. m.		8,296,680	78.0		2.5	1.2				50,769	240	624						16.5	5.15	14.20	830	.2	148.8	150.6
6.40 p. m.		8,301,760	78.5		2.5	1.2				52,805	241	624						16.5	5.10	14.15	820	.2	147.2	148.0
7 p. m.	300	8,306,550	78.5		2.5	1.2	720,800			54,845	242	609	330		.4	4.0								
7.20 p. m.		8,311,350	78.5		2.5	1.2				56,885	241	624												
7.40 p. m.		8,316,000	79.0		2.6	1.3				58,929	240	614			.4	4.0	17.0	5.00	14.20	810	.2	147.6	148.8	
7.45 p. m.	300																							
8 p. m.		8,320,650	79.5		2.5	1.2	723,750			60,953	240	624	280					17.0	5.20	14.90	830	.2	150.5	161.8
8.20 p. m.		8,325,570	79.5		2.5	1.2				62,984	240	624						17.0	5.10	13.20	820	.2	129.7	131.5
8.30 p. m.	300																							
8.40 p. m.		8,330,490	79.5		2.5	1.2				65,015	240	624						17.5	5.20	14.20	830	.2	149.0	151.3
9 p. m.		8,335,600	80.0		2.4	1.2	728,710			67,063	241	624	355					18.0	5.20	14.50	830	.2	152.8	155.5
9.15 p. m.	300																							
9.20 p. m.		8,340,700	81.5		2.4	1.2				69,099	240	634			.45	5.0	18.0	5.20	14.20	850	.2	151.6	154.3	
9.40 p. m.		8,346,900	81.5		2.4	1.2				71,139	241	624						18.0	5.20	14.35	850	.2	144.0	146.5
10 p. m.	300	8,351,210	81.5		2.4	1.2	729,900			72,985	241	624	380					18.0	5.00	13.80	850	.2	148.4	150.8

December 16.

" December 16.

Log of producer-gas test No. 16, Wyoming No. 2 coal, December 16, 17, 1904—Continued.

Time.	Coal consumed by producer (pounds).	Manometers at gas meter (inches water).				Auxiliary motors. on gas engine.				Speed counters on gas engine.				Load. Volts. Amperes.	Manometers at producer.				Temperatures (°C.).				Gas calorimeter.				B. T. U.					
		1.		2.		1.		2.		1.		2.			Temperature of gas leaving producer (°C.).		Air entering (inches mer-cury).		Gas leaving (inches wa-ter).		Gas.		Water.		Cubic centimeters of water collected.				Cubic feet of gas.			
		Temp. of gas (° F.).		Water meter (cubic feet).		Watt meter.		Ammeter.		1.		2.			1.		2.		1.		2.		1.		2.				1.		2.	
		3	4	5	6	7	8	9	10	11	12	13	14		15	16	17	18	19	20	21	22	23									
10.40 a. m.		8,563,740	78.0		2.2	0.5				144,008	239	624				0.55	4.5	17.5	5.00	12.10	980	0.2	138.1	140.3								
11 a. m.		8,559,900	78.0		2.3	.6	770,650			146,035	242	624	410				18.0	5.00	13.15	920	.2	146.8	149.4									
11.15 a. m.	300																															
11.20 a. m.		8,565,650	78.0		2.4	.9				148,070	240	629					17.5	5.00	12.40	1,050	.2	153.9	156.1									
11.40 a. m.		8,571,400	78.0		2.4	.9				150,100	241	624					17.8	4.95	12.55	900	.2	144.8	147.1									
12 m.	300	8,576,900	78.0		2.5	1.0	774,100			152,130	239	614	520	.6	5.5	17.0	5.00	12.80	970	.2	150.0	152.1										
12.20 p. m.		8,582,700	77.5		2.4	.4				154,159	241	624					17.3	5.00	12.40	900	.2	145.2	147.3									
12.40 p. m.		8,588,350	77.5		2.5	1.0				156,198	242	624					17.0	5.00	12.20	1,180	.2	168.6	171.0									
12.45 p. m.	300																															
1 p. m.		8,593,500	78.0		2.5	1.1	777,300			158,237	241	624	490				17.5	5.00	13.20	900	.2	146.4	148.6									
1.20 p. m.		8,598,600	78.5		2.5	1.1				160,277	242	624					18.0	4.80	13.70	900	.2	158.7	161.4									
1.30 p. m.	300																															
1.40 p. m.		8,603,550	79.0		2.5	1.1				162,319	241	624				.45	4.5	19.0	5.00	14.00	880	.2	157.1	160.5								
2 p. m.		8,608,710	79.5		2.5	1.1	780,600			164,357	242	624	390				18.8	5.00	13.90	890	.2	157.1	160.4									
2.15 p. m.	300																															
2.20 p. m.		8,613,810	79.5		2.5	1.0				166,390	242	624					18.5	4.95	13.85	870	.2	153.6	156.6									
2.40 p. m.		8,618,750	79.5		2.5	1.1				168,434	242	624					18.0	5.00	13.90	870	.2	153.6	156.2									
3 p. m.	400	8,623,590	79.0		2.5	1.1	783,800			170,473	239	624	390	.55	5.0	17.5	4.80	13.60	870	.2	152.0	154.3										
3.20 p. m.		8,628,400	78.5		2.5	1.1				172,500	238	634					17.0	4.90	13.20	870	.2	143.2	145.2									
3.40 p. m.		8,633,250	78.0		2.5	1.2				174,532	240	624					16.4	4.80	13.00	900	.2	146.4	148.1									
4 p. m.		8,638,050	77.5		2.5	1.2	786,980			176,564	240	624	390				16.0	4.80	13.30	830	.2	142.1	143.6									

OPERATIONS OF THE COAL-TESTING PLANT.

GAS ANALYSES.

Time.	CO ₂ .	O ₂ .	CO.	H ₂ .	CH ₄ .	N.	Total.	B. T. U.
10.45 a. m. ^a	9.2	3.2	13.8	12.2	5.0	56.6	100.0	144.7
12.05 p. m.	8.8	.6	19.0	8.2	4.5	58.9	100.0	122.8
2.05 p. m.	9.0	.8	18.4	11.7	4.0	56.1	100.0	146.5
4.05 p. m.	8.6	.0	18.0	14.9	3.4	55.1	100.0	150.8
6.05 p. m.	9.2	.2	17.6	8.4	6.8	57.8	100.0	163.0
8.05 p. m.	9.8	.2	17.4	12.2	6.1	54.3	100.0	167.9
10.05 p. m.	9.4	2.2	12.6	11.0	6.3	58.5	100.0	149.0
12.05 a. m. ^b	10.4	.4	15.2	10.7	5.9	57.4	100.0	153.1
2.05 a. m.	10.0	.0	16.8	13.5	5.3	54.4	100.0	162.1
4.05 a. m.	12.0	.0	13.0	9.6	4.8	60.6	100.0	129.8
6.05 a. m.	11.8	.0	14.4	8.9	6.5	58.4	100.0	141.5
8.05 a. m.	11.6	.0	13.4	7.2	7.2	60.6	100.0	148.5
10.05 a. m.	12.0	.4	12.2	11.5	5.4	58.5	100.0	140.1
12 m.	11.0	.4	13.8	9.0	6.0	59.8	100.0	143.4
2 p. m.	10.4	.4	16.4	12.8	5.6	54.4	100.0	162.4

^aDecember 16.

^bDecember 17.

Producer-gas test No. 16, Wyoming No. 2 coal.

[Recorded by W. C. Weidmann, Kurt Toensfeldt, and R. E. Peshak, December 16, 17, 1904.]

1. Duration of test, in hours.....	30
AVERAGE TEMPERATURE, ° F.	
2. Gas leaving producer.....	680
3-6. (See footnote on p. 1027.)	
OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
7. Total steam used by producer.....pounds..	7,470
8. Steam used by producer per hour.....do....	249
9. Equivalent in pounds of coal per hour.....	56.5
10. Equivalent in pounds of dry coal per hour.....	51.2
11. Equivalent in pounds of combustible per hour.....	39.5
12. Average horsepower required to drive auxiliary machinery.....	16.4
COAL CONSUMED IN PRODUCER.	
16. Total coal consumed.....pounds..	12,100
17. Moisture in coal.....per cent..	9.44
18. Total dry coal consumed.....pounds..	10,958
19. Refuse from dry coal.....per cent..	22.90
20. Total refuse from coal.....pounds..	2,509
21. Total combustible consumed.....do....	8,449

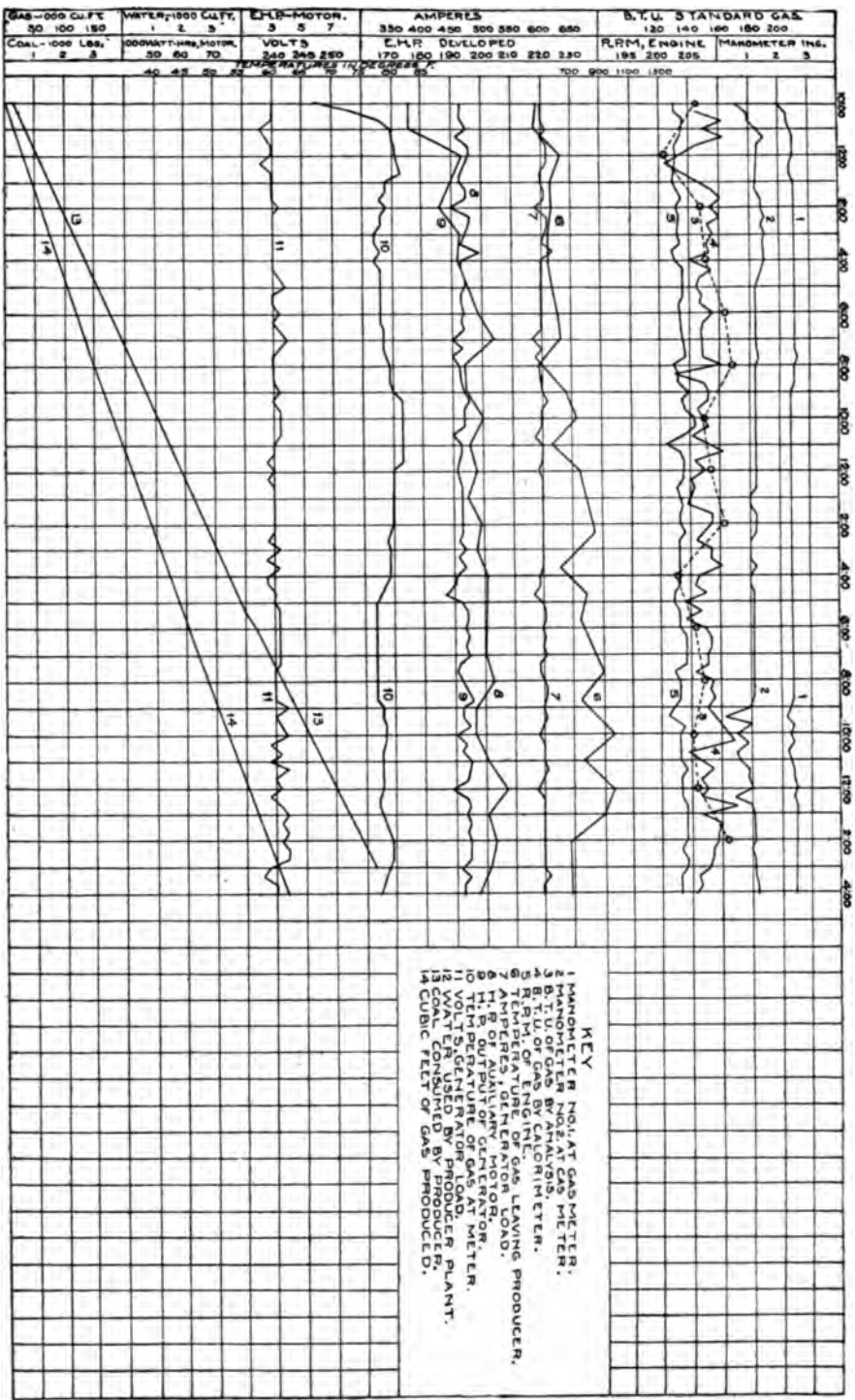


FIG. 131.—Graphical log sheet, producer-gas test, Wyoming No. 2 coal.

OPERATIONS OF THE COAL-TESTING PLANT.

COAL PER HOUR.

22. Coal consumed in producer.....	pounds..	403. 3
23. Dry coal consumed in producer.....	do....	365. 3
24. Combustible consumed in producer.....	do....	281. 6
25. Equivalent coal used by producer plant.....	do....	459. 8
26. Equivalent dry coal used by producer plant.....	do....	416. 5
27. Equivalent combustible used by producer plant.....	do....	321. 1

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

28. Coal as fired	pounds..	10. 50
29. Dry coal.....	do....	9. 50
30. Combustible.....	do....	7. 30

BRITISH THERMAL UNITS FROM COAL.

31. Per pound of coal as fired.....	9, 650
32. Per pound of dry coal.....	10, 656
33. Per pound of combustible.....	13, 820
34. From coal as fired, per hour.....	3, 891, 400
35. From dry coal, per hour.....	3, 892, 600
36. From combustible, per hour.....	3, 891, 800

GAS PRODUCED, CUBIC FEET.

[Gas at 62° F. and 14.7 pounds pressure.]

37. Total.....	447, 700
38. Per hour.....	14, 923
39. Per pound coal consumed in producer.....	37
40. Per pound dry coal consumed in producer.....	40. 9
41. Per pound combustible consumed in producer.....	53
42. Per pound equivalent coal used by producer plant.....	32. 5
43. Per pound equivalent dry coal used by producer plant.....	35. 8
44. Per pound equivalent combustible used by producer plant.....	46. 5

BRITISH THERMAL UNITS FROM STANDARD GAS.

45. Per cubic foot.....	151
46. Per pound dry coal burned in producer.....	6, 168
47. Per hour per brake horsepower.....	9, 516

AVERAGE HORSEPOWER DEVELOPED.

48. Electrical horsepower available for outside purposes.....	184. 8
49. Electrical horsepower developed at switch board.....	201. 2
50. Brake horsepower available for outside purposes.....	217. 4
51. Brake horsepower developed at engine.....	236. 8

EFFICIENCIES.

52. Of conversion and cleaning gas.....	. 580
53. Of producer plant.....	. 500

PRODUCER-GAS TESTS.

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COAL PER HORSEPOWER PER HOUR.

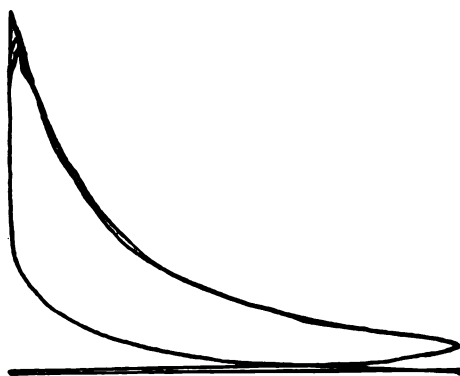
	Coal as fired.	Dry coal.	Combustible.
54. Pounds consumed in producer per electrical horsepower available for outside purposes.....	2. 18	1. 98	1. 52
55. Pounds consumed in producer per electrical horsepower developed at switch board.....	2. 00	1. 82	1. 40
56. Pounds consumed in producer per brake horsepower ^a available for outside purposes.....	1. 86	1. 68	1. 30
57. Pounds consumed in producer per brake horsepower ^a developed at engine.....	1. 70	1. 54	1. 19
58. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes.....	2. 49	2. 25	1. 74
59. Equivalent pounds used by producer plant per electrical horsepower developed at switch board.....	2. 28	2. 07	1. 60
60. Equivalent pounds used by producer plant per brake horsepower ^a available for outside purposes.....	2. 11	1. 92	1. 48
61. Equivalent pounds used by producer plant per brake horsepower ^a developed at engine.....	1. 94	1. 76	1. 36

^a Based on an assumed efficiency of 85 per cent for generator and belt.

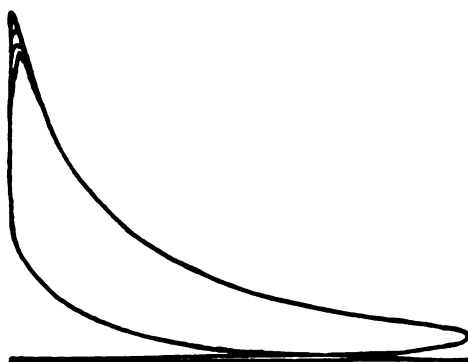
AVERAGE COMPOSITION OF COAL AND GAS.

62. Coal:	Per cent.	63. Gas by volume:	Per cent.
Moisture.....	9. 44	Carbon dioxide (CO ₂).....	10. 21
Volatile matter.....	35. 02	Oxygen (O ₂).....	. 59
Fixed carbon.....	34. 82	Carbon monoxide (CO).....	15. 46
Ash.....	20. 72	Hydrogen (H ₂).....	10. 79
	100. 00	Methane (CH ₄).....	5. 52
		Nitrogen (N ₂).....	57. 43
Sulphur.....	3. 91		100. 00

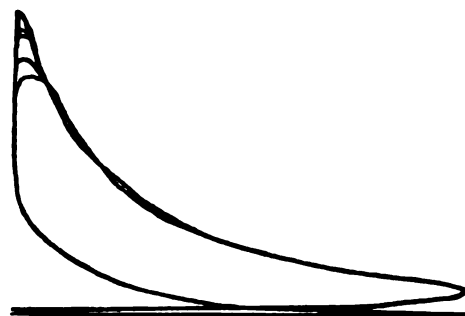
Wyoming No. 2 is a bituminous coal. It burned without any clinkering, leaving a large amount of white ash similar to that obtained from wood. The gas was not uniform in quality, on account of the difficulty experienced in keeping the



Right cylinder. M. E. P., 59; Max., 300; Rel., 26; I. H. P., 94.4.



Center cylinder. M. E. P., 60; Max., 270; Rel., 27; I. H. P., 95.9.



Left cylinder. M. E. P., 51; Max., 224; Rel., 26; I. H. P., 81.6.

Indicator diagrams taken December 16, 1904, during gas-engine test No. 16, on Wyoming No. 2 coal. Scale of spring, 80; revolutions per minute, 202.5.

bed in good condition, which made more or less trouble in securing the proper mixture of air and gas. There was also some slight trouble with the ignition setting. Sixty gallons of yellow tar were taken from the gas.

PRODUCER-GAS TESTS.

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GAS ENGINE.

Following are results of tests on the gas engine:

Report of gas-engine test No. 16.

Recorded by K. Toensfeldt and W. C. Weidmann, December 16, 17, 1904.

Producer test No. 16.

Coal: General number, Wyoming No. 2; special number, G. P., 16. Car initials and number, C. B. and Q. 72534.

Duration of test, in hours.....	30
Revolutions per minute (mean).....	203.2
Explosions per minute (mean).....	101.6
Cubic feet gas per hour, by meter.....	15,583
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure).....	14,913
Maximum pressure:	
First cylinder.....	244.5
Second cylinder.....	262.6
Third cylinder.....	241.2
Pressure at release:	
First cylinder.....	27.4
Second cylinder.....	28.6
Third cylinder.....	26.8
Mean effective pressure:	
First cylinder.....	57.66
Second cylinder.....	56.46
Third cylinder.....	50.40
Indicated horsepower:	
First cylinder.....	92.31
Second cylinder.....	90.3
Third cylinder.....	80.66
Total indicated horsepower.....	263.27
Horsepower delivered (electrical horsepower).....	201.2
Mechanical efficiency (engine and generator combined)..... per cent..	76.4
Cubic feet standard gas per hour per indicated horsepower.....	56.6
Cubic feet standard gas per hour per electrical horsepower.....	74.1

SUMMARY OF RESULTS.

The table given herewith shows in a condensed form the results obtained in the producer-gas tests.

The chart which follows the table presents in a compact manner the most important items. As will be seen at a glance, the coals are arranged in the order of their economic value as determined by the tests already made. The order of precedence may be slightly modified in the light of future tests, conducted under improved conditions, although it is doubtful if it is seriously shaken.

Brief summary of 24 producer-gas tests of bituminous coals and lignites.

No. of test.	Date of test.	Dura- tion in hours.	Name of sample.	Coal per hour (pounds).					
				Consumed in producer.			Equivalent used by pro- ducer plant.		
				Coal as fired.	Dry coal.	Combustible.	Coal as fired.	Dry coal.	Combustible.
1	2	3	4	5	6	7	8	9	10
2	Oct. 10-14.....	43.00	Alabama No. 2.....	310.5	299.0	280.0	341.4	328.7	306.8
15	Dec. 13-14.....	30.00	Colorado No. 1.....	364.4	290.7	269.3	428.4	341.7	316.6
a6	Oct. 31-Nov. 1..	30.00	Illinois No. 3.....	350.0	323.3	289.3	386.0	356.7	319.2
a9	Nov. 10-11.....	30.00	Illinois No. 4.....	350.0	306.3	274.1	398.2	348.5	311.9
a14	Dec. 2-3.....	29.67	Indiana No. 1.....	394.5	349.3	309.5	434.6	384.8	341.0
a13	Nov. 28-29.....	7.00	Indiana No. 2.....	300.0	274.0	244.8	338.0	312.0	278.8
1	Oct. 3-6.....	31.00	Indian Territory No. 1.....	361.0	344.0	312.0	392.7	374.0	339.3
20	Jan. 23-24.....	22.67	Indian Territory No. 4.....	278.0	253.2	207.8	312.5	284.6	233.6
22	Jan. 30-31.....	13.33	Iowa No. 2.....	362.5	302.5	227.5	408.4	340.7	256.2
24	Feb. 6-7.....	13.00	Kansas No. 5.....	307.8	294.3	259.8	338.4	323.6	285.7
a12	Nov. 25-26.....	30.00	Kentucky No. 3.....	370.0	343.3	310.0	410.8	381.2	344.2
a7	Nov. 3.....	4.33	Missouri No. 2.....	346.5	306.0	255.0	384.5	339.6	283.0
a5	Oct. 24-25.....	22.33	Montana No. 1.....	456.5	404.5	355.8	506.8	449.1	395.0
a10	Nov. 14-15.....	30.00	North Dakota No. 2.....	460.0	278.0	249.0	510.0	308.0	275.8
a11	Nov. 21-22.....	21.67	Texas No. 1.....	590.0	393.0	332.0	660.0	439.5	371.3
18	Dec. 21-22.....	19.33	Texas No. 2.....	468.0	310.3	276.2	519.5	344.4	306.6
3	Oct. 17-18.....	24.00	West Virginia No. 1.....	287.5	283.0	265.5	320.6	315.6	296.1
4	Oct. 20.....	9.00	West Virginia No. 4.....	233.0	229.0	208.0	262.8	258.2	234.5
23	Feb. 2-3.....	22.67	West Virginia No. 7.....	264.9	256.9	239.1	299.2	290.2	270.1
19	Jan. 20-21.....	21.00	West Virginia No. 8.....	328.6	320.0	301.1	364.7	355.1	334.1
17	Dec. 19.....	6.33	West Virginia No. 9.....	300.0	292.0	274.9	328.9	320.1	301.4
21	Jan. 27-28.....	24.00	West Virginia No. 9.....	250.0	244.5	227.0	284.8	278.5	258.6
a8	Nov. 7-8.....	30.00	West Virginia No. 12.....	270.0	266.1	248.7	304.9	300.5	280.9
16	Dec. 16-17.....	30.00	Wyoming No. 2.....	403.3	365.3	281.6	459.8	416.5	321.1

* Gas-producer hopper leaked during these tests.

PRODUCER-GAS TESTS.

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Brief summary of 24 producer-gas tests of bituminous coals and lignites—Continued.

No. of test.	Date of test.	Dura- tion in hours.	Name of sample.	British thermal units.					
				Coal as fired, per pound.	Dry coal, per pound.	Combustible, per pound.	Percubic foot of standard gas.	From standard gas per pound of dry coal consumed in producer.	From standard gas per hour per horse- power.
1	2	3	4	11	12	13	14	15	16
2	Oct. 10-14.....	43.00	Alabama No. 2.....	12,865	13,365	14,820	149.2	9,000	11,420
15	Dec. 13-14.....	30.00	Colorado No. 1.....	9,767	12,245	13,210	149.0	7,860	9,700
a6	Oct. 31-Nov. 1.....	30.00	Illinois No. 3.....	12,046	13,041	14,560	154.8	8,330	11,460
a9	Nov. 10-11.....	30.00	Illinois No. 4.....	11,237	12,834	14,344	151.5	8,840	11,620
a14	Dec. 2-3.....	29.67	Indiana No. 1.....	11,534	13,037	14,720	153.7	7,730	11,480
a13	Nov. 28-29.....	7.00	Indiana No. 2.....	11,822	12,953	14,500	159.3	10,140	11,750
1	Oct. 3-6.....	31.00	Indian Territory No. 1.....	12,787	13,455	14,800	159.2	8,620	12,350
20	Jan. 23-24.....	22.67	Indian Territory No. 4.....	10,364	11,392	13,890	161.1	9,980	10,750
22	Jan. 30-31.....	13.33	Iowa No. 2.....	8,735	10,489	13,960	160.2	9,300	12,130
24	Feb. 6-7.....	13.00	Kansas No. 5.....	12,836	13,421	15,200	167.2	10,500	13,130
a12	Nov. 25-26.....	30.00	Kentucky No. 3.....	12,283	13,226	14,650	155.9	8,610	12,540
a7	Nov. 3.....	4.33	Missouri No. 2.....	10,505	11,882	14,280	140.0	8,820	11,500
a5	Oct. 24-25.....	22.33	Montana No. 1.....	10,575	11,934	13,580	160.8	6,580	11,340
a10	Nov. 14-15.....	30.00	North Dakota No. 2.....	6,802	11,255	12,600	188.5	7,830	13,770
a11	Nov. 21-22.....	21.67	Texas No. 1.....	7,267	10,928	12,945	169.7	7,260	12,230
18	Dec. 21-22.....	19.33	Texas No. 2.....	7,348	11,086	12,450	156.2	8,060	10,570
3	Oct. 17-18.....	24.00	West Virginia No. 1.....	14,166	14,396	15,350	144.4	9,260	11,130
4	Oct. 20.....	9.00	West Virginia No. 4.....	13,918	14,202	15,600	143.2	11,610	11,320
23	Feb. 2-3.....	22.67	West Virginia No. 7.....	14,283	14,720	15,800	154.2	13,140	14,380
19	Jan. 20-21.....	21.00	West Virginia No. 8.....	14,168	14,558	15,470	155.1	9,070	12,340
17	Dec. 19.....	6.33	West Virginia No. 9.....	14,195	14,580	15,500	151.0	8,150	10,060
21	Jan. 27-28.....	24.00	West Virginia No. 9.....	14,224	14,548	15,650	160.5	11,380	11,860
a8	Nov. 7-8.....	30.00	West Virginia No. 12.....	14,614	14,825	15,860	142.5	10,150	11,500
16	Dec. 16-17.....	30.00	Wyoming No. 2.....	9,650	10,656	13,820	151.0	6,168	9,516

a Gas-producer hopper leaked during these tests.

OPERATIONS OF THE COAL-TESTING PLANT.

Brief summary of 24 producer-gas tests of bituminous coals and lignites—Continued.

No. of test.	Date of test.	Dura- tion in hours.	Name of sample.	Cubic feet of standard gas produced (62° F., 14.7 pounds pressure).						
				Per hour.	Per pound consumed in producer.			Per pound equivalent used by producer plant.		
					Coal as fired.	Dry coal.	Com- busti- ble.	Coal as fired.	Dry coal.	Com- busti- ble.
1	2	3	4	17	18	19	20	21	22	23
2	Oct. 10-14.....	43.00	Alabama No. 2.....	18,050	58.1	60.4	64.5	52.9	55.0	58.9
15	Dec. 13-14.....	30.00	Colorado No. 1.....	15,343	42.1	52.8	57.0	35.8	44.9	48.5
a 6	Oct. 31-Nov. 1.....	30.00	Illinois No. 3.....	17,412	49.8	53.9	60.2	45.1	48.8	54.5
a 9	Nov. 10-11.....	30.00	Illinois No. 4.....	17,881	51.1	58.4	65.3	44.8	51.4	57.4
a 14	Dec. 2-3.....	29.67	Indiana No. 1.....	17,560	44.5	50.3	56.7	40.4	45.6	51.5
a 13	Nov. 28-29.....	7.00	Indiana No. 2.....	17,450	58.2	63.6	71.3	51.6	55.9	62.6
1	Oct. 3-6.....	31.00	Indian Territory No. 1.....	18,613	51.6	54.1	59.4	47.4	49.9	54.6
20	Jan. 23-24.....	22.67	Indian Territory No. 4.....	15,680	56.4	61.9	75.5	50.2	55.1	67.1
22	Jan. 30-31.....	13.33	Iowa No. 2.....	17,570	48.5	58.1	77.2	43.0	51.6	68.5
24	Feb. 6-7.....	13.00	Kansas No. 5.....	18,490	60.1	62.8	71.2	54.6	57.2	64.8
a 12	Nov. 25-26.....	30.00	Kentucky No. 3.....	18,943	51.2	55.1	61.1	46.2	49.7	55.0
a 7	Nov. 3.....	4.33	Missouri No. 2.....	19,300	55.7	63.0	75.7	50.2	56.8	68.2
a 5	Oct. 24-25.....	22.33	Montana No. 1.....	16,540	36.2	40.9	46.5	32.6	36.8	41.9
a 10	Nov. 14-15.....	30.00	North Dakota No. 2.....	11,550	25.2	41.5	46.4	22.7	37.5	41.9
a 11	Nov. 21-22.....	21.67	Texas No. 1.....	16,800	28.4	42.7	50.6	25.5	38.2	45.3
18	Dec. 21-22.....	19.33	Texas No. 2.....	16,009	34.2	51.6	57.9	30.8	46.4	52.2
3	Oct. 17-18.....	24.00	West Virginia No. 1.....	18,150	63.2	64.1	68.4	56.6	57.5	61.3
4	Oct. 20.....	9.00	West Virginia No. 4.....	18,560	79.6	81.2	89.2	70.6	71.9	79.2
23	Feb. 2-3.....	22.67	West Virginia No. 7.....	21,850	82.5	85.1	91.4	73.0	75.3	80.9
19	Jan. 20-21.....	21.00	West Virginia No. 8.....	18,690	56.9	58.4	62.0	51.3	52.6	55.9
17	Dec. 19.....	6.33	West Virginia No. 9.....	15,770	52.6	54.0	57.4	48.0	49.3	52.3
21	Jan. 27-28.....	24.00	West Virginia No. 9.....	17,330	69.3	70.9	76.3	60.9	62.2	67.0
a 8	Nov. 7-8.....	30.00	West Virginia No. 12.....	18,957	70.1	71.2	76.2	62.1	63.2	67.5
16	Dec. 16-17.....	30.00	Wyoming No. 2.....	14,923	37.0	40.9	53.0	32.5	35.8	46.5

a Gas-producer hopper leaked during these tests.

PRODUCER-GAS TESTS.

1319

Brief summary of 24 producer-gas tests of bituminous coals and lignites—Continued.

No. of test.	Date of test.	Dura- tion in hours.	Name of sample.	Economic results: Pounds of coal consumed in producer per horsepower per hour.					
				Per electrical horsepower available for outside pur- poses.			Per electrical horsepower developed at switch board.		
				Coal as fired.	Dry coal.	Combustible.	Coal as fired.	Dry coal.	Combustible.
1	2	3	4	24	25	26	27	28	29
2	Oct. 10-14.....	43.00	Alabama No. 2.....	1.61	1.55	1.45	1.55	1.49	1.40
15	Dec. 13-14.....	30.00	Colorado No. 1.....	1.95	1.56	1.45	1.82	1.45	1.35
a 6	Oct. 31-Nov. 1.....	30.00	Illinois No. 3.....	1.82	1.68	1.50	1.75	1.62	1.45
a 9	Nov. 11-11.....	30.00	Illinois No. 4.....	1.85	1.62	1.45	1.76	1.55	1.38 ^a
a 14	Dec. 2-3.....	29.67	Indiana No. 1.....	2.10	1.86	1.64	1.97	1.75	1.55
a 13	Nov. 28-29.....	7.00	Indiana No. 2.....	1.57	1.43	1.28	1.49	1.36	1.22
1	Oct. 3-6.....	31.00	Indian Territory No. 1.....	1.84	1.76	1.59	1.77	1.69	1.53
20	Jan. 23-24.....	22.67	Indian Territory No. 4.....	1.48	1.35	1.10	1.39	1.27	1.04
22	Jan. 30-31.....	13.33	Iowa No. 2.....	1.94	1.62	1.22	1.84	1.53	1.15
24	Feb. 6-7.....	13.00	Kansas No. 5.....	1.60	1.53	1.35	1.54	1.47	1.30
a 12	Nov. 25-26.....	30.00	Kentucky No. 3.....	1.95	1.81	1.63	1.85	1.71	1.55
a 7	Nov. 3.....	4.33	Missouri No. 2.....	1.87	1.65	1.37	1.74	1.54	1.28
a 5	Oct. 24-25.....	22.33	Montana No. 1.....	2.39	2.12	1.86	2.29	2.03	1.78
a 10	Nov. 14-15.....	30.00	North Dakota No. 2.....	3.67	2.22	1.99	3.42	2.07	1.66
a 11	Nov. 21-22.....	21.67	Texas No. 1.....	3.16	2.10	1.78	2.98	1.99	1.68
18	Dec. 21-22.....	19.33	Texas No. 2.....	2.47	1.64	1.46	2.33	1.54	1.37
3	Oct. 17-18.....	24.00	West Virginia No. 1.....	1.51	1.49	1.40	1.43	1.41	1.33
4	Oct. 20.....	9.00	West Virginia No. 4.....	1.23	1.21	1.10	1.17	1.15	1.04
23	Feb. 2-3.....	22.67	West Virginia No. 7.....	1.41	1.37	1.27	1.33	1.29	1.20
19	Jan. 20-21.....	21.00	West Virginia No. 8.....	1.73	1.68	1.58	1.64	1.60	1.51
17	Dec. 19.....	6.33	West Virginia No. 9.....	1.60	1.56	1.47	1.49	1.46	1.37
21	Jan. 27-28.....	24.00	West Virginia No. 9.....	1.32	1.29	1.20	1.26	1.23	1.14
a 8	Nov. 7-8.....	30.00	West Virginia No. 12.....	1.41	1.39	1.30	1.35	1.33	1.24
16	Dec. 16-17.....	30.00	Wyoming No. 2.....	2.18	1.98	1.52	2.00	1.82	1.40

^a Gas-producer hopper leaked during these tests.

Brief summary of 24 producer-gas tests of bituminous coals and lignites—Continued.

No. of test.	Date of test.	Dura- tion in hours.	Name of sample.	Economic results: Pounds of coal consumed in producer per horsepower per hour.					
				Per brake horsepower avail- able for outside purposes.			Per brake horsepower devel- oped at engine.		
				Coal as fired.	Dry coal.	Combust- ible.	Coal as fired.	Dry coal.	Combust- ible.
1	2	3	4	30	31	32	33	34	35
2	Oct. 10-14.....	43.00	Alabama No. 2.....	1.37	1.32	1.23	1.32	1.27	1.19
15	Dec. 13-14.....	30.00	Colorado No. 1.....	1.66	1.32	1.23	1.55	1.23	1.14
a 6	Oct. 31-Nov. 1.....	30.00	Illinois No. 3.....	1.54	1.43	1.28	1.49	1.38	1.23
a 9	Nov. 10-11.....	30.00	Illinois No. 4.....	1.57	1.37	1.23	1.50	1.31	1.17
a 14	Dec. 2-3.....	29.67	Indiana No. 1.....	1.78	1.58	1.40	1.68	1.49	1.32
a 13	Nov. 28-29.....	7.00	Indiana No. 2.....	1.33	1.22	1.09	1.27	1.16	1.03
1	Oct. 3-6.....	31.00	Indian Territory No. 1.....	1.57	1.50	1.36	1.50	1.43	1.30
20	Jan. 23-24.....	22.67	Indian Territory No. 4.....	1.26	1.15	.94	1.18	1.08	.89
22	Jan. 30-31.....	13.33	Iowa No. 2.....	1.65	1.38	1.04	1.56	1.30	.98
24	Feb. 6-7.....	13.00	Kansas No. 5.....	1.36	1.30	1.15	1.31	1.25	1.10
a 12	Nov. 25-26.....	30.00	Kentucky No. 3.....	1.66	1.54	1.39	1.57	1.46	1.32
a 7	Nov. 3.....	4.33	Missouri No. 2.....	1.59	1.40	1.17	1.48	1.31	1.09
a 5	Oct. 24-25.....	22.33	Montana No. 1.....	2.03	1.80	1.58	1.95	1.72	1.52
a 10	Nov. 14-15.....	30.00	North Dakota No. 2.....	3.13	1.89	1.69	2.91	1.76	1.58
a 11	Nov. 21-22.....	21.67	Texas No. 1.....	2.68	1.79	1.51	2.54	1.69	1.43
18	Dec. 21-22.....	19.33	Texas No. 2.....	2.10	1.39	1.24	1.98	1.31	1.17
3	Oct. 17-18.....	24.00	West Virginia No. 1.....	1.29	1.27	1.19	1.22	1.20	1.13
4	Oct. 20.....	9.00	West Virginia No. 4.....	1.05	1.03	.94	.99	.98	.89
23	Feb. 2-3.....	22.67	West Virginia No. 7.....	1.20	1.16	1.08	1.13	1.10	1.02
19	Jan. 20-21.....	21.00	West Virginia No. 8.....	1.47	1.43	1.35	1.40	1.36	1.28
17	Dec. 19.....	6.33	West Virginia No. 9.....	1.36	1.33	1.25	1.27	1.24	1.16
21	Jan. 27-28.....	24.00	West Virginia No. 9.....	1.18	1.10	1.02	1.07	1.04	.97
a 8	Nov. 7-8.....	30.00	West Virginia No. 12.....	1.20	1.18	1.11	1.15	1.13	1.06
16	Dec. 16-17.....	30.00	Wyoming No. 2.....	1.86	1.68	1.30	1.70	1.54	1.19

a Gas-producer hopper leaked during these tests.

Brief summary of 24 producer-gas tests of bituminous coals and lignites—Continued.

No. of test.	Date of test.	Dura- tion in hours.	Name of sample.	Economic results: Equivalent pounds of coal used by producer plant per horsepower per hour.					
				Per electrical horsepower available for outside pur- poses.			Per electrical horsepower de- veloped at switch board.		
				Coal as fired.	Dry coal.	Combust- ible.	Coal as fired.	Dry coal.	Combust- ible.
1	2	3	4	36	37	38	39	40	41
2	Oct. 10-14.....	43.00	Alabama No. 2.....	1.77	1.71	1.59	1.71	1.64	1.53
15	Dec. 13-14.....	30.00	Colorado No. 1.....	2.30	1.83	1.70	2.14	1.71	1.58
a 6	Oct. 31-Nov. 1.....	30.00	Illinois No. 3.....	2.01	1.85	1.66	1.93	1.79	1.60
a 9	Nov. 10-11.....	30.00	Illinois No. 4.....	2.11	1.84	1.65	2.01	1.76	1.57
a 14	Dec. 2-3.....	29.67	Indiana No. 1.....	2.31	2.04	1.81	2.17	1.93	1.71
a 13	Nov. 28-29.....	7.00	Indiana No. 2.....	1.77	1.63	1.46	1.68	1.55	1.39
1	Oct. 3-6.....	31.00	Indian Territory No. 1.....	2.00	1.91	1.73	1.92	1.83	1.66
20	Jan. 23-24.....	22.67	Indian Territory No. 4.....	1.66	1.51	1.24	1.57	1.43	1.17
22	Jan. 30-31.....	13.33	Iowa No. 2.....	2.19	1.83	1.37	2.07	1.73	1.30
24	Feb. 6-7.....	13.00	Kansas No. 5.....	1.76	1.68	1.49	1.69	1.62	1.43
a 12	Nov. 25-26.....	30.00	Kentucky No. 3.....	2.16	2.01	1.81	2.05	1.91	1.72
a 7	Nov. 3.....	4.33	Missouri No. 2.....	2.07	1.83	1.52	1.94	1.71	1.43
a 5	Oct. 24-25.....	22.33	Montana No. 1.....	2.65	2.35	2.07	2.54	2.25	1.98
a 10	Nov. 14-15.....	30.00	North Dakota No. 2.....	4.07	2.46	2.20	3.80	2.29	2.05
a 11	Nov. 21-22.....	21.67	Texas No. 1.....	3.53	2.35	1.99	3.34	2.22	1.88
18	Dec. 21-22.....	19.33	Texas No. 2.....	7.2	1.82	1.62	2.58	1.71	1.52
3	Oct. 17-18.....	24.00	West Virginia No. 1.....	1.69	1.66	1.56	1.60	1.57	1.48
4	Oct. 20.....	9.00	West Virginia No. 4.....	1.39	1.36	1.24	1.32	1.29	1.17
23	Feb. 2-3.....	22.67	West Virginia No. 7.....	1.59	1.55	1.44	1.50	1.46	1.36
19	Jan. 20-21.....	21.00	West Virginia No. 8.....	1.92	1.87	1.76	1.82	1.78	1.67
17	Dec. 19.....	6.33	West Virginia No. 9.....	1.76	1.71	1.61	1.64	1.59	1.50
21	Jan. 27-28.....	24.00	West Virginia No. 9.....	1.51	1.47	1.37	1.43	1.40	1.30
a 8	Nov. 7-8.....	30.00	West Virginia No. 12.....	1.59	1.57	1.47	1.53	1.50	1.40
16	Dec. 16-17.....	30.00	Wyoming No. 2.....	2.49	2.25	1.74	2.28	2.07	1.60

a Gas-producer hopper leaked during these tests.

Brief summary of 24 producer-gas tests of bituminous coals and lignites—Continued.

No. of test.	Date of test.	Dura- tion in hours.	Name of sample.	Economic results: Equivalent pounds of coal used by producer plant per horsepower per hour.					
				Per brake horsepower avail- able for outside purposes.			Per brake horsepower devel- oped at engine.		
				Coal as fired.	Dry coal.	Combus- tible.	Coal as fired.	Dry coal.	Combus- tible.
1	2	3	4	42	43	44	45	46	47
2	Oct. 10-14.....	43.00	Alabama No. 2.....	1.51	1.45	1.35	1.45	1.40	1.30
15	Dec. 13-14.....	30.00	Colorado No. 1.....	1.95	1.56	1.44	1.82	1.45	1.34
a 6	Oct. 31-Nov. 1.....	30.00	Illinois No. 3.....	1.70	1.58	1.41	1.64	1.52	1.36
a 9	Nov. 10-11.....	30.00	Illinois No. 4.....	1.79	1.56	1.40	1.71	1.50	1.34
a 14	Dec. 2-3.....	29.67	Indiana No. 1.....	1.96	1.74	1.54	1.85	1.64	1.45
a 13	Nov. 28-29.....	7.00	Indiana No. 2.....	1.52	1.39	1.24	1.43	1.32	1.18
1	Oct. 3-6.....	31.00	Indian Territory No. 1.....	1.71	1.62	1.47	1.64	1.56	1.41
20	Jan. 23-24.....	22.67	Indian Territory No. 4.....	1.41	1.29	1.06	1.33	1.21	1.00
22	Jan. 30-31.....	13.33	Iowa No. 2.....	1.86	1.55	1.17	1.76	1.47	1.10
24	Feb. 6-7.....	13.00	Kansas No. 5.....	1.50	1.43	1.26	1.44	1.37	1.21
a 12	Nov. 25-26.....	30.00	Kentucky No. 3.....	1.84	1.71	1.54	1.75	1.62	1.46
a 7	Nov. 3.....	4.33	Missouri No. 2.....	1.76	1.55	1.30	1.65	1.45	1.21
a 5	Oct. 24-25.....	22.33	Montana No. 1.....	2.26	2.00	1.76	2.16	1.91	1.68
a 10	Nov. 14-15.....	30.00	North Dakota No. 2.....	3.47	2.09	1.88	3.23	1.95	1.74
a 11	Nov. 21-22.....	21.67	Texas No. 1.....	3.00	2.20	1.69	2.83	1.99	1.60
18	Dec. 21-22.....	19.33	Texas No. 2.....	2.33	1.55	1.38	2.20	1.46	1.30
3	Oct. 17-18.....	24.00	West Virginia No. 1.....	1.43	1.41	1.33	1.36	1.34	1.26
4	Oct. 20.....	9.00	West Virginia No. 4.....	1.18	1.16	1.05	1.12	1.10	1.00
23	Feb. 2-3.....	22.67	West Virginia No. 7.....	1.35	1.31	1.22	1.28	1.24	1.15
19	Jan. 20-21.....	21.00	West Virginia No. 8.....	1.63	1.59	1.49	1.55	1.51	1.42
17	Dec. 19.....	6.33	West Virginia No. 9.....	1.49	1.46	1.37	1.39	1.35	1.27
21	Jan. 27-28.....	24.00	West Virginia No. 9.....	1.28	1.25	1.16	1.21	1.19	1.10
a 8	Nov. 7-8.....	30.00	West Virginia No. 12.....	1.35	1.34	1.25	1.30	1.28	1.20
16	Dec. 16-17.....	30.00	Wyoming No. 2.....	2.11	1.92	1.48	1.94	1.76	1.36

a Gas-producer hopper leaked during these tests.

PRODUCER-GAS TESTS.

1323

Brief summary of 24 producer-gas tests of bituminous coals and lignites—Continued.

No. of test.	Date of test.	Dura- tion in hours.	Name of sample.	Average composition of gas by volume (per cent).					
				Carbonic acid (CO ₂).	Oxygen (O ₂).	Carbonic oxide (CO).	Hydro- gen (H ₂).	Marsh gas (CH ₄).	Nitrogen (N ₂).
1	2	3	4	48	49	50	51	52	53
2	Oct. 10-14.....	43.00	Alabama No. 2.....	8.16	0.10	16.65	7.20	5.64	62.24
15	Dec. 13-14.....	30.00	Colorado No. 1.....	10.11	.55	17.38	11.05	5.00	55.90
a 6	Oct. 31-Nov. 1.	30.00	Illinois No. 3.....	10.53	.15	15.31	8.35	4.46	61.19
a 9	Nov. 10-11.....	30.00	Illinois No. 4.....	9.72	.12	15.12	9.98	6.00	59.06
a 14	Dec. 2-3.....	29.67	Indiana No. 1.....	9.89	.25	14.10	9.56	6.08	60.13
a 13	Nov. 28-29.....	7.00	Indiana No. 2.....	11.80	.07	11.46	10.60	6.10	59.97
1	Oct. 3-6.....	31.00	Indian Territory No. 1.....	8.25	.11	19.39	7.69	4.92	59.65
20	Jan. 23-24.....	22.67	Indian Territory No. 4.....	7.290	.236	17.636	10.427	6.30	58.109
22	Jan. 30-31.....	13.33	Iowa No. 2.....	10.057	.171	12.571	9.529	7.671	60.000
24	Feb. 6-7.....	13.00	Kansas No. 5.....	10.267	.133	12.40	9.05	7.417	60.733
a 12	Nov. 25-26.....	30.00	Kentucky No. 3.....	10.87	.29	12.45	10.92	6.52	58.96
a 7	Nov. 3.....	4.33	Missouri No. 2.....	12.07	.20	10.53	7.63	6.33	63.23
a 5	Oct. 24-25.....	22.33	Montana No. 1.....	9.04	.36	18.67	8.00	4.84	59.10
a 10	Nov. 14-15.....	30.00	North Dakota No. 2.....	8.69	.23	20.90	14.33	4.85	51.02
a 11	Nov. 21-22.....	21.67	Texas No. 1.....	11.10	.22	14.43	10.54	7.48	56.22
18	Dec. 21-22.....	19.33	Texas No. 2.....	9.60	.20	18.22	9.63	4.81	57.53
3	Oct. 17-18.....	24.00	West Virginia No. 1.....	10.50	.10	14.34	2.81	5.56	66.69
4	Oct. 20.....	9.00	West Virginia No. 4.....	10.16	.24	15.82	11.16	3.74	58.88
23	Feb. 2-3.....	22.67	West Virginia No. 7.....	9.617	.084	12.75	10.308	6.758	60.483
19	Jan. 20-21.....	21.00	West Virginia No. 8.....	10.327	.218	11.927	9.454	6.40	61.672
17	Dec. 19.....	6.33	West Virginia No. 9.....	10.40	.20	13.70	9.55	6.60	59.55
21	Jan. 27-28.....	24.00	West Virginia No. 9.....	8.90	.33	14.77	9.508	6.65	59.856
a 8	Nov. 7-8.....	30.00	West Virginia No. 12.....	10.34	.12	14.21	12.98	4.61	57.75
16	Dec. 16-17.....	30.00	Wyoming No. 2.....	10.21	.59	15.46	10.79	5.52	57.43

a Gas-producer hopper leaked during these tests.

In considering the possible increase in efficiency of the boiler tests if a compound engine should be substituted for the simple engine used, the fact should not be overlooked that a corresponding increase in the efficiency of the gas-producer tests may be brought about under the most favorable conditions. The gas engine is passing through a transitional period. In the larger sizes the vertical single-acting engine is being replaced by the horizontal double-acting. Other changes and improvements are constantly being made which tend to do for the gas engine what compounding and tripling the expansions have done for the steam engine.

The gas engine used in the trials recorded is a vertical three-cylinder, single-acting engine with no means of changing the ignition while the engine is running.

In the tests at hand a glance at the "British thermal units per hour per brake horsepower" will show in many instances that the ignition setting was faulty, thus causing an excessive amount of gas to be used. With a variable ignition device there is no doubt that marked improvement can be shown in the amount of gas used by the engine.

The producer itself was subjected to new and varied conditions for which it was not well adapted. In the light of the information which has been obtained during the operation of this plant, together with the changes and improvements that will naturally be made in the construction and operation of producer plants for use in connection with bituminous coals and lignites, there is every reason to expect a development in this particular line which will make a marked increase in the efficiency of such installations.

A brief consideration of these points will lead at once to the conclusion that the gas engine and steam engine used in these tests compare very favorably, and that any increase in efficiency in the boiler tests that might result from using a compound engine can be offset by the introduction of the more modern type of gas engine and the improved producer plant.

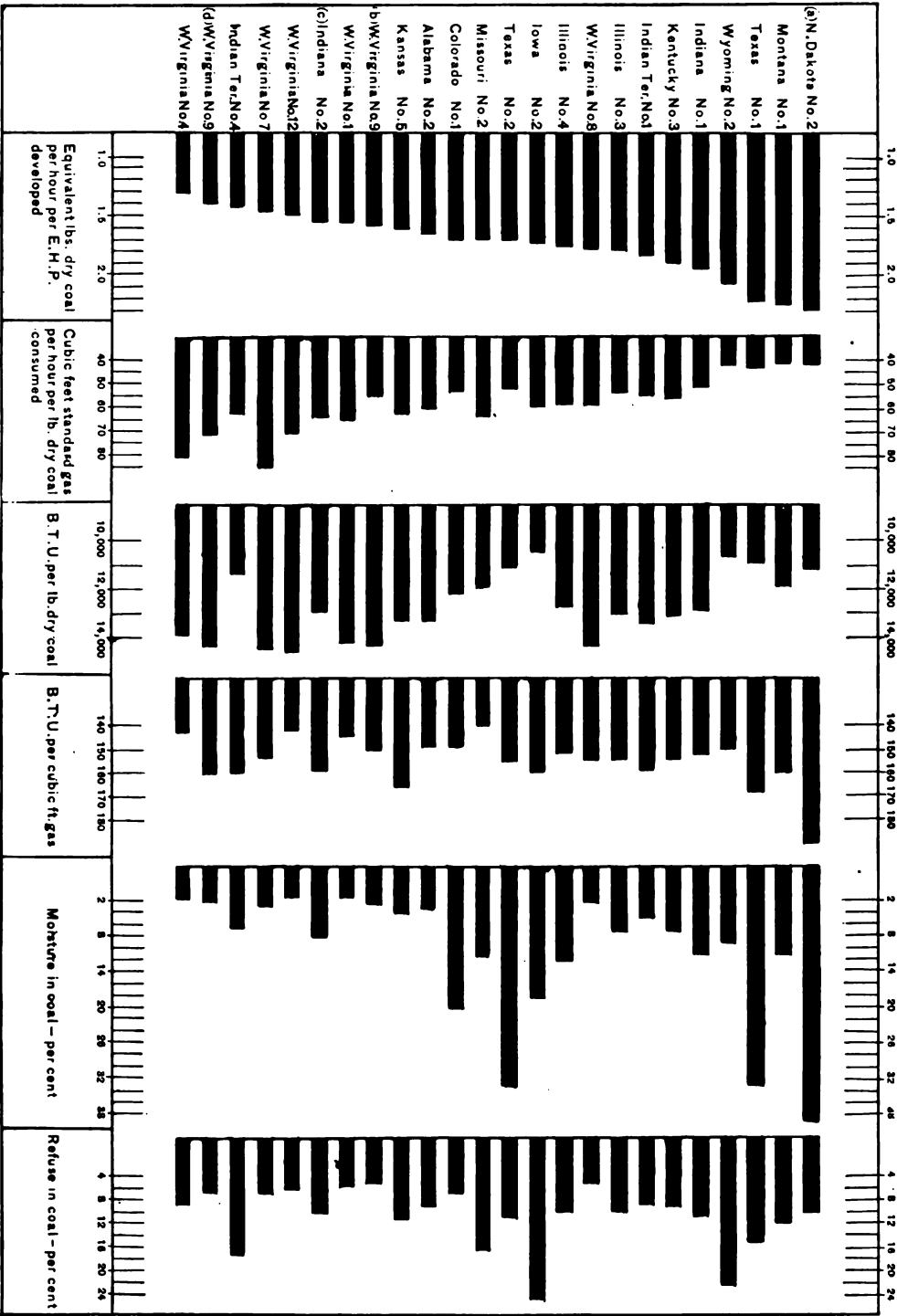


Fig. 135.—Graphic summary of producer-gas tests of 24 coals and lignites.

COKING TESTS.

By FRED. W. STAMMLER.

INTRODUCTION.

The tests of the coking qualities of the coals received at the testing plant were made in a battery of three bee-hive ovens. The ovens are of standard size and shape, 12 feet in diameter and 7 feet high, and they were built from plans furnished by Mr. John Fulton, the well-known expert on coke making, of Johnstown, Pa. The writer was assisted in making the coking tests by Mr. B. B. Boyd, of Uniontown, Pa. The analyses given in the table at the end of this report of coals that were charged in the coke ovens, and of the resulting cokes, were all made at the chemical laboratory of the testing plant, under the direction of Prof. N. W. Lord, of Columbus, Ohio.

The ovens were fired on September 10, and were kept in blast until December 16. During this time 61 tests were made, embracing 44 different coals, coming from 11 States. Thirty-two tests were made on 29 different samples of raw coal, and 27 tests were made on 24 samples of washed coal. Two tests were made on briquettes of noncoking coal, having an additional amount of volatile matter used as a binding material. All of the coal charged into the ovens was first passed through rolls, reducing it to 1½ inches or smaller.

RESULTS OF TESTS.

The results of the coking tests have been arranged alphabetically by States, the general number adopted for all tests being given for ready identification, and are as follows:

ALABAMA No. 1.

Coking test No. 8, on unwashed coal; coking test No. 13, on washed coal.—Lump and nut coal from mine No. 8, Ivy Coal and Iron Company, Horse Creek, Ala.

Two charges were made of this coal, the first being unwashed and the second washed. The first charge of unwashed coal consisted of 8,000 pounds. Although the coking process was continued for 88 hours, the coke was very light, of a spongy structure, and high in ash. Washing reduced the percentage of impurities but

slightly, though it is believed that with more thorough washing a coke of good quality might be obtained. The charge of washed coal weighed 9,800 pounds, was burned for 65 hours, and produced 5,731 pounds of coke,^a a percentage yield of 58.5. This coke was also soft and high in ash. The results of the tests are shown below.

Analysis of Alabama No. 1 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1142	2.65	30.79	52.68	13.88	0.76	Used for coking test No. 8.
Washed.....	1199	4.64	31.28	53.02	11.06	.89	Used for coking test No. 13.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged.					Total coke made.	Per cent of yield.			
				Wet.	Dry.	Large coke made.	Medium coke made.	Breeze and ash.		Large.	Medium.	Total.	Breeze and ash.
			Hrs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.				
8 (unwashed)...	Sept. 29, 4 p. m.	Oct. 3, 8 a. m....	88	.....	8,000	.....	.....	.....	.....	.....	.....	.....	.....
13 (washed)...	Oct. 7, 4 p. m....	Oct. 10, 9 a. m....	65	9,800	.....	4,215	1,516	5,731	352	43.0	15.4	58.5	3.6

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
							Lbs.	Feet.				P. ct.	P. ct.	Per ct.	Per ct.	P. ct.	P. ct.
13	10.1	18.45	38.38	70.11	49	51	145	58	2.0	1.94	1220	0.33	0.72	82.63	16.32	0.69	0.047

Coke, mostly in large pieces, was produced from this coal. Some pieces were of good color and ring, others were dark gray, and were soft and spongy. The large amount of ash in the coal was also noticeable in the coke. The washed coal showed a lower percentage of ash, but not sufficiently low to insure a desirable fuel. Washing did not materially improve the quality of the coke, as the coke from the washed coal was soft and would not carry a heavy burden. The sulphur and phosphorus are low, and the cell structure approaches that of Connellsville coke, but the ash is rather high. If this can be reduced by proper washing this coke may come up to standard.

^a Exclusive of 352 pounds of breeze and ash.

ALABAMA No. 2.

Coking test No. 7.—Lump, nut, and pea coal from mine No. 5, Galloway Coal Company, Carbon Hill, Ala.

The coal used in this test was unwashed, the charge weighing 8,000 pounds. It coked imperfectly in small pieces, which were very soft, and which were mixed with charred coal and ash. The coal is high in ash (13.04 per cent), but if properly washed may yield a coke of fair grade. The results are summarized as follows:

Analysis of Alabama No. 2 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Unwashed.....	1136	3.77	32.60	50.59	13.04	1.43	Used for coking test No. 7.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Remarks.
			<i>Hours.</i>	<i>Pounds.</i>	
7 (unwashed).....	Sept. 28, 4 p. m....	Oct. 1, 8 a. m.....	64	8,000	Small coke.

The coal charged burned freely with a hot flame, giving a good, hot oven. When the oven was discharged, it was noticed that the coke produced was all in small pieces, very friable, with no bond to hold together, and was mixed with burnt coal and ashes. The lower part of the charge was not coked at all. What coke was obtained was fit only for domestic fuel. Washing might improve it, as the ash and sulphur are high in the coal, and could be reduced.

ARKANSAS No. 1.

Coking test No. 5.—Lump and nut coal from mine No. 3, Central Coal and Coke Company, Huntington, Ark.

The charge consisted of 8,075 pounds of unwashed coal, which showed no tendency to coke and burned to ash. The volatile constituents are too low to make coke in the beehive oven. If properly washed, this coal may make coke in a retort oven. It is high in ash (13.01 per cent), and also somewhat high in sulphur.

Analysis of Arkansas No. 1 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Unwashed.....	1107	2.31	18.10	66.58	13.01	1.13	Used for coking test No. 5.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Remarks.
			Hours.	Pounds.	
5 (unwashed).....	Sept. 22, 2 p. m...	Sept. 27, 8 a. m...	114	8,075	No coke.

The coal charge ignited freely and burned for about one day, when it died out, turned black on top, and the oven cooled off. When the charge was drawn, it was found that all the volatile matter or gas was driven off, and all that remained in the oven looked like burnt sand mixed with some small lumps of coal. No fusing or coking was noticeable.

ARKANSAS No. 2.

Coking test No. 4.—Lump coal from mine No. 12, Central Coal and Coke Company, Bonanza, Ark. Same result as obtained from Arkansas No. 1, as shown below:

Analysis of Arkansas No. 2 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1102	2.31	17.41	69.73	10.55	1.58	Used for coking test No. 4.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Remarks.
			Hours.	Pounds.	
4 (unwashed).....	Sept. 21, 10 a. m...	Sept. 26, 8 a. m...	118	8,150	No coke.

The coal started off nicely, producing sufficient gas to heat the crown of the oven to a light-red heat, which kept up for about 24 hours, when the charge turned black, and the oven got cold. When the charge was drawn, it was found that the gas or volatile matter had been driven off and the residue was in the shape of sandy ashes, intermixed with a few pieces of coal, nut size. No fusing or coking could be observed. Good steam coal, but noncoking.

ARKANSAS No. 3.

Coking test No. 61.—Lump and slack coal from mine No. 18, Western Coal and Mining Company, Jenny Lind, Ark. This was an experimental charge of a small amount of briquettes made from unwashed coal and placed in an oven with

a coking coal. The briquettes contained 6 per cent of hard pitch, and they produced a dense coke high in ash. Following are the results:

Analysis of Arkansas No. 3 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed mine sample		1.50	16.50	72.00	10.00	1.40	Used for coking test No. 61.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).
			Hours.	Pounds.
61 (briquettes)	Oct. 15, 4 p. m.	Oct. 18, 9 a. m.	65	309

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot (dry).	Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Chemical laboratory number.	Chemical analysis.				
	Dry.	Wet.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
				Pounds.	Feet.			Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
61	14.4		54.72	190	76	2.3	1299	1.05	2.80	72.73	23.42	1.52

To ascertain how the Arkansas coal would act if mixed with some additional binder, a box of briquettes was put into an oven with some other coal to be coked. The briquettes were made of 95 per cent of coal and 5 per cent of pitch. The results showed a dense, close coke, very dirty, with a poor ring. The analysis shows the coke to be high in ash and sulphur. The coke stood the compression test well, but the hardness was below standard. Coke made in this way could be used for many purposes, but for metallurgical fuel it is not desirable, being too high in ash and sulphur.

ARKANSAS No. 6.

Coking test No. 58.—Slack coal from mine No. 18, Western Coal and Mining Company, Jenhy Lind, Ark.

The behavior of these two coals in the ovens was practically the same as that of Arkansas No. 1, except that No. 6 was washed and the percentage of ash shows a noticeable reduction.

The charge for a second test consisted of equal parts of unwashed coal crushed and mixed with 8 per cent of hard pitch, and the same material made into briquettes on the English machine. The addition of the pitch, by increasing the volatile matter, caused the coal to fuse and produced coke. The coke, however, was very dark, and had large cells. The test is interesting, since it shows that a

naturally noncoking coal may be made to coke by the addition of pitch. This charge weighed 8,000 pounds, was burned 42 hours, and yielded 4,056 pounds of coke and 539 pounds of breeze and ash. The results of this test are as follows:

Analysis of Arkansas No. 6 coal.

Character of coal.	Chem- ical lab- oratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Washed.....	1538	18.29	12.95	62.54	6.22	1.22	Used for coking test No. 58.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (wet).
			<i>Hours.</i>	<i>Pounds.</i>
58 (washed).....	Dec. 8, 3 p. m.....	Dec. 12, 2 p. m ...	95	9,000

This coal acted the same as the other Arkansas coals. The gas was driven off and the residue was in the shape of sandy ashes, intermixed with a few pieces of coal about the size of a man's fist. No fusing or coking could be noticed. The volatile matter was exceedingly low in this coal.

ARKANSAS NO. 6 COAL, WITH 8 PER CENT OF PITCH.

Coking test No. 55.—Slack from mine of Western Coal and Mining Company located at Jenny Lind, Ark.

Results from mixture: Dark-gray coke, no metallic ring, high in ash.

Analysis of Arkansas No. 6 coal and pitch.

Character of coal.	Chem- ical lab- oratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Mixture.....	1518	4.59	17.25	64.12	14.04	1.68	Used for coking test No. 55.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Per cent of yield.						
				Coal charged (dry).	Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Large.	Medium.
			<i>Hours.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>		<i>Total.</i>
55.....	Dec. 5, 3 p. m.....	Dec. 7, 9 a. m.....	42	a 7,360	2,639	1,417	4,056	539	32.9	17.7

a Coal only, to which was added 640 pounds pitch, making 8,000 pounds of coal and pitch.

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
55....	13.7	22.38	52.06	85.04	47	53	Lbs. 162	Feet. 65	2.1	1.88	1535	P. ct. 4.06	P. ct. 2.77	P. ct. 76.63	P. ct. 16.54	P. ct. 1.43	P. ct. 0.05

Coal mixed with 8 per cent of pitch, one-half of which was pressed into briquettes, the balance being loose, was charged and resulted in dark-gray coke, with large cells and no metallic ring. Ash, sulphur, and phosphorus were high, and hardness was low, as were also the burden-bearing qualities. This coke was better than that made of briquettes made from Arkansas No. 5 coal and can be used where high ash and sulphur are not important considerations.

ILLINOIS No. 1.

Coking test No. 10.—Lump and nut coal from mine No. 1, Western Anthracite Coal and Coke Company, O'Fallon, Ill.

This test was made on a charge of 9,000 pounds of unwashed coal, which was burned for 43 hours. It produced some small pieces of coke, mixed with charred coal and ash. The coal is too high in ash (15.95 per cent) and sulphur (4.14 per cent) to produce a coke fit for blast-furnace use.

Analysis of Illinois No. 1 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1162	10.46	36.11	37.48	15.95	4.14	Used for coking test No. 10.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Remarks.
			Hours.	Pounds.	
10 (unwashed).....	Oct. 3, 3 p. m.....	Oct. 5, 10 a. m.....	43	9,000	No valuable coke.

The coal was charged into a very hot oven. After 12 hours the charge lay dead and it required some extra charges of wood to keep the oven heated. When discharged the oven contained some small pieces of coke, mixed with charred coal and ashes, not fit for any use.

ILLINOIS No. 2.

Coking test No. 9.—Slack coal from the same mine as No. 1.

This coal was washed (p. 1462) before charging into the ovens, reducing the ash to 9.19 per cent. The amount of coal charged was 9,000 pounds, which, after burning 64 hours, yielded 3,389 pounds of mixed hard and soft coke, and 352 pounds of breeze and ash. The coke contained 20.18 per cent of ash and 2.75 per cent of sulphur.

Analysis of Illinois No. 2 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1162	10.46	36.11	37.48	15.95	4.14	Same as Illinois No. 1.
Washed.....	1159	17.20	35.77	37.84	9.19	3.03	Used for coking test No. 9.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (wet).	Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
									Large.	Medium.	Total.	Breeze and ash.
9 (washed)	Oct. 1, 4 p. m.....	Oct. 4, 8 a. m.....	Hours. 64	Lbs. 9,000	Lbs. 2,264	Lbs. 1,125	Lbs. 3,389	Lbs. 352	25.1	12.5	37.6	3.9

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.						
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.	
9.....	13.2	21.71	50.16	82.49	48	52	Lbs. 135	Feet. 54	2.2	1.87	1211	P. ct. 1.57	P. ct. 2.83	P. ct. 75.42	P. ct. 20.18	P. ct. 2.75	P. ct. 0.030	

This washed coal, which is from the same mine as Illinois No. 1, produced a fair-looking coke. Some pieces were hard, with good cell structure and metallic ring, while others were soft and brittle, of grayish color. The coke was lacking in uniformity, which might be improved by proper crushing and mixing of the coal. Owing to the high percentage of sulphur, which appears in the shape of gypsum in the coal and can not be removed by washing or burning, the coke can not be

used for blast furnaces or cupolas, but it will be useful for lead or zinc works. The washing showed that a large amount of impurities can be removed and that it changed the coal from a noncoking to a coking coal.

ILLINOIS No. 3.

Coking tests Nos. 28 and 29.—Run-of-mine coal from mine No. 3, Southern Illinois Coal Mining and Washing Company, near Marion, Ill.

Two charges were made of this coal, one unwashed, the other washed. The unwashed charge of 9,000 pounds was tested for 43 hours. The coal lay dead in the oven, burning on top, but did not coke. The unwashed coal contained 10.59 per cent ash. The washed charge carried 5.86 per cent ash, being a reduction of nearly 50 per cent (p. 1467). This charge of washed coal consisted of 13,000 pounds and was burned 90 hours, yielding 6,378 pounds of coke, which was very brittle and which broke up in handling into fine-fingered pieces. The breeze and ash in this oven weighed 834 pounds.

Analysis of Illinois No. 3 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1337	8.25	30.32	50.94	10.59	1.45	Used for coking test No. 29.
Washed.....	1326	9.52	32.05	52.57	5.86	1.41	Used for coking test No. 28.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged.		Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
				Wet.	Dry.					Large.	Medium.	Total.	Breeze and ash.
			Hrs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.				
29 (unwashed)	Nov. 1, 2 p. m.	Nov. 3, 9 a. m.	43	.....	9,000	.....	.....	.....	.....	.....	.....	.....	.....
28 (washed)...	Oct. 29, 2 p. m.	Nov. 2, 8 a. m.	90	13,000	.....	1,508	4,870	6,378	834	11.6	37.4	49.0	6.4

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
							Lbs.	Feet.				P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
28....	12.3	21.30	46.74	80.94	45	55	210	84	2.6	1.84	1343	6.11	0.42	82.55	10.92	1.13	0.019

The unwashed coal lay dead in the oven, burnt on top, but would not coke. It was changed to a coking coal by washing. The coke produced was all in fine-fingered pieces, none thicker than 1 inch, and very brittle, light, and friable, breaking up in handling. The chemical analysis showed ash, sulphur, and phosphorus to be about the same as standard. The cell structure was high, but the hardness and burden-bearing qualities were lower than those of Connellsville coke. It can be used in blast furnaces, but is better for cupolas.

ILLINOIS No. 5.

Coking tests Nos. 45, 59, and 60.—Grade No. 5, washed slack from mine No. 1, Donk Brothers Coal and Coke Company, Collinsville, Ill.

Three tests were made of this coal, as it was reported that it had been coked successfully in pits. All of the coal was washed before charging and each charge was burned for 42 hours. In the first test the coal was charged as it was received, but no coke was produced. In the second test the coal was rewashed through the New Century jig (p. 1467), but it was charged wet and the oven was chilled and the coal would not burn. In the last test the oven was heated by an extra charge of coal and the charge was made in a red-hot oven, but even with this precaution the coal would not coke. In each instance the coal burned out on top, but otherwise lay dead in the oven and would not coke under existing conditions. All of the Illinois coals are too high in sulphur to make good blast-furnace coke.

Analysis of Illinois No. 5 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
Washed:		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
No. 1.....	1454	17.86	31.65	32.93	17.56	3.25	Used for coking test No. 45.
No. 2.....	1546	25.15	28.68	36.99	9.18	2.71	Used for coking test No. 59.
No. 3.....	1554	14.60	30.76	36.48	18.16	3.44	Used for coking test No. 60.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (wet).	Remarks.
			<i>Hours.</i>	<i>Pounds.</i>	
45 (washed).....	Nov. 21, 3 p. m....	Nov. 23, 9 a. m....	42	8,000	No coke.
59 (washed).....	Dec. 10, 3 p. m....	Dec. 12, 9 a. m....	42	5,000	Do.
60 (washed).....	Dec. 13, 3 p. m....	Dec. 15, 9 a. m....	42	9,000	Do.

The charge lay dead in the oven. It burned on top, but would not coke, producing only charred pieces of coal, mixed with ashes. Even if this coal had produced coke it would not be fit for metallurgical purposes on account of its high ash and sulphur.

INDIANA NO. 1.

Coking test No. 51.—Run-of-mine coal from Mildred mine, J. Woolley Coal Company, Mildred, Ind.

This coal was crushed and washed (pp. 1463–1464). The charge consisted of 8,000 pounds and was burned for 40 hours. It produced 3,473 pounds of fair coke of medium weight, bright gray, but brittle and rather high in sulphur. The breeze and ash amounted to 368 pounds.

Analysis of Indiana No. 1 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Washed.....	1497	16.53	36.38	40.05	7.04	2.03	Used for coking test No. 51.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (wet).	Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
									Large.	Medium.	Total.	Breeze and ash.
51 (washed)....	Nov. 29, 4 p. m...	Dec. 1, 8 a. m....	<i>Hours.</i> 40	<i>Lbs.</i> 8,000	<i>Lbs.</i> 2,452	<i>Lbs.</i> 1,021	<i>Lbs.</i> 3,473	<i>Lbs.</i> 368	30.6	12.7	43.4	4.6

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
51....	12.8	21.15	48.64	80.37	49	51	<i>Lbs.</i> 175	<i>Feet.</i> 70	2.5	1.86	1511	<i>P. ct.</i> 5.71	<i>P. ct.</i> 1.18	<i>P. ct.</i> 80.52	<i>P. ct.</i> 12.59	<i>P. ct.</i> 1.69	<i>P. ct.</i> 0.016

The coke produced was of a light-gray color, with a fair cell structure, in hardness and burden-bearing qualities not up to standard. With proper washing the percentage of ash could be reduced. A large amount of sulphur is volatilized in coking. The coke may be used profitably where high sulphur is no disadvantage.

INDIAN TERRITORY No. 1.

Coking test No. 6.—Lump and slack coal from mine No. 1, Whitehead Coal and Mining Company, Henryetta, Ind. T.

This test was made on 8,095 pounds of unwashed coal. It lasted 40 hours, and nothing but ash was left in the oven. The coal showed no tendency to coke.

Analysis of Indian Territory No. 1 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Unwashed.....	1132	10.29	31.46	44.39	13.86	1.34	Used in coking test No. 6.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Remarks.
			<i>Hours.</i>	<i>Pounds.</i>	
6 (unwashed).....	Sept. 27, 4 p. m....	Sept. 29, 8 a. m....	40	8,095	No coke.

The coal charge burned freely with a hot flame. When the oven was drawn it was found that the gas was driven off and a few small pieces of coke had been formed, full of cracks. The balance consisted of small pieces of charred coal mixed with fine ashes. It is a good steam coal but not coking.

INDIAN TERRITORY No. 2.

Coking tests Nos. 11 and 12.—Run-of-mine coal from mine No. 8, Rock Island Coal Company, Hartshorne, Ind. T.

Two tests were made on this coal, washed and unwashed. Both charges weighed 9,000 pounds. The unwashed charge was burned for 66 hours, and yielded 5,725 pounds of coke and 580 pounds of breeze and ash. The coke was very soft, shattered and brittle, and somewhat high in sulphur. The washed charge contained one-third less ash than the unwashed (p. 1338). It was burned for 65 hours, producing a coke which was hard and which had a fairly good ring. It showed considerable improvement in appearance over the coke made from unwashed coal, but the sulphur content was higher.

Analysis of Indian Territory No. 2 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1169	3.82	37.45	48.74	9.99	1.47	Used for coking test No. 11.
Washed.....	1179	4.45	38.18	51.04	6.33	1.43	Used for coking test No. 12.

Coking test and coke production.

Test number.	When charged.	When drawn.	Coal charged.						Per cent of yield.			
			Time in oven.			Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Large.	Medium.	Total.
				Wet.	Dry.							
			Hrs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.			
11 (unwashed).	Oct. 4, 1 p. m....	Oct. 7, 9 a. m....	68		9,000	2,367	3,358	5,725	580	26.3	37.3	63.6
12 (washed)....	Oct. 5, 3 p. m....	Oct. 8, 8 a. m....	65	9,000		3,523	1,157	4,680	255	39.1	12.8	52.0

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
11....	11.0	19.35	41.80	73.53	48	52	Lbs. 93	Feet. 37	2.0	1.88	1212	P. ct. 8.15	P. ct. 1.74	P. ct. 75.68	P. ct. 14.43	P. ct. 1.50	P. ct. 0.05
12....	11.6	20.11	44.08	76.41	49	51	178	71	2.5	1.82	1219	.96	2.59	85.33	11.12	1.75	.043

From the unwashed coal was produced a soft coke, shattered and brittle, with high ash, sulphur, and phosphorus. An improvement could be noticed with the product from the washed coal. The coke had a good appearance, a good cell structure, and its hardness and burden-bearing qualities were increased. Sulphur and phosphorus are high. The coke had a good ring. As the sulphur was higher in the coke from washed coal we must assume that the washing was not very effective and could be improved.

INDIAN TERRITORY NO. 3.

Coking tests Nos. 21 and 22.—Run-of-mine coal from mine No. 1, D. Edwards & Sons, Edwards, Ind. T.

Two tests were made on this coal, the first being on 12,000 pounds of unwashed coal, burned 65 hours, and the second on 14,000 pounds washed coal, burned 66 hours. The washed coal, instead of showing a reduced percentage of sulphur,

showed a gain (see analysis below). Neither charge yielded coke. The ovens when drawn contained small pieces of charred coal and ash.

Analysis of Indian Territory No. 3 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1266	4.16	36.66	49.43	9.75	3.16	Used for coking test No. 21.
Washed.....	1272	5.93	38.05	48.63	7.49	3.20	Used for coking test No. 22.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged.		Remarks.
				Wet.	Dry.	
			Hours.	Pounds.	Pounds.	
21 (unwashed).....	Oct. 18, 5 p. m....	Oct. 21, 10 a. m....	65		12,000	No coke.
22 (washed).....	Oct. 19, 3 p. m....	Oct. 22, 9 a. m....	66	14,000		Do.

In both tests with unwashed and washed coal the same results were obtained. The coal burned freely, the gas was driven off, and the residue consisted of a few pieces of small coke mixed with charred coal and ashes. The coal is a good steam coal, but noncoking and high in sulphur.

INDIAN TERRITORY No. 5.

Coking test No. 48.—Slack and pea coal from mine No. 7, Western Coal and Mining Company, Lehigh, Ind. T.

This test was made on 10,000 pounds of washed coal (p. 1468) and was continued for 65 hours. It produced some small pieces of coke, fritted together, light and soft. The general conclusion regarding the Territory coals tested is that when properly washed they will produce coke, but not of a character suited for iron smelting, as the sulphur is too intimately combined or mixed with the coal to be removed by washing.

Analysis of Indian Territory No. 5 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Washed.....	1476	16.95	33.30	41.61	8.14	2.90	Used for coking test No. 48.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (wet).	Remarks.
			Hours.	Pounds.	
48 (washed).....	Nov. 25, 4 p. m....	Nov. 28, 9 a. m....	65	10,000	No coke.

The results of the test with this coal were small pieces of light coke, nut size, fritted together, very friable and brittle, being easily broken. The coke may be used for domestic purposes, but is useless as metallurgical fuel. Sulphur in coal was very high. The coal must be considered noncoking.

IOWA No. 1.

Coking test No. 31.—Lump and fine coal from mine No. 2, Anchor Coal Company, Laddsdale, Iowa.

In this test, as in all those on Iowa coals, the charge was of washed coal (p. 1469). The charge weighed 9,500 pounds, and after burning 46 hours yielded 4,828 pounds of coke and 572 pounds of breeze and ash. The coke was brittle, with cracks lengthwise and crosswise through it. It was also high in sulphur and ash.

Analysis of Iowa No. 1 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Washed.....	1356	12.84	35.91	41.00	10.25	4.61	Used for coking test No. 31.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (wet).	Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
									Large.	Medium.	Total.	Breeze and ash.
31 (washed) ...	Nov. 3, 3 p. m	Nov. 5, 1 p. m	<i>Hours</i> 46	<i>Lbs.</i> 9,500	<i>Lbs.</i> 916	<i>Lbs.</i> 3,912	<i>Lbs.</i> 4,828	<i>Lbs.</i> 572	9.5	41.2	50.8	6.0

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
31....	11.4	19.75	43.32	75.05	49	51	Lbs. 180	Feet. 72	2.2	1.87	1371	P. ct. 10.53	P. ct. 1.63	P. ct. 70.39	P. ct. 17.45	P. ct. 3.89	P. ct. 0.051

The coke produced with this washed coal showed cracks lengthways and cross-ways. It was very brittle and broke up into small pieces in handling. These pieces seemed to be fairly hard and of good cell structure. The ash, sulphur, and phosphorus are high, making the coke unfit for blast furnace and foundry purposes, and the smallness of the pieces would make it undesirable for use in lead or zinc works.

IOWA No. 2.

Coking test No. 49.—Run-of-mine coal from mine No. 5, Mammoth Vein Coal Company, Hamilton, Iowa.

The charge in this test consisted of 10,000 pounds of washed coal (p. 1469), which was burned for 64 hours. The coke (3,866 pounds, with 1,153 pounds of breeze and ash) was all in small pieces sintered together and with no bond.

Analysis of Iowa No. 2 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Washed.....	1483	18.85	35.44	35.43	10.28	3.93	Used for coking test No. 49.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (wet).	Total coke made.	Breeze and ash.
			<i>Hours.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
49 (washed).....	Nov. 26, 5 p. m ...	Nov. 29, 9 a. m ...	64	10,000	3,866	1,153

This charge made some coke, all in small pieces, sintered together, which broke up in drawing so that ash and breeze formed one-fourth of the total product. This coke could be used only for domestic purposes and would not be very desirable, even for such use, on account of its high ash and sulphur. The small-sized pieces of this coke would make a poor fuel at lead or zinc furnaces.

IOWA No. 3.

Coking test No. 35.—Lump coal from mine No. 4, Gibson Coal Mining Company, Altoona, Iowa.

The charge in this test consisted of 8,000 pounds of washed coal (p. 1469), which was burned for 43 hours. It yielded 3,336 pounds of fine-fingered, brittle coke that was high in sulphur and ash, and 585 pounds of breeze and ash.

Analysis of Iowa No. 3 coal.

Character of coal.	Chemical laboratory number.	Moisture	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Washed.....	1399	16.83	39.27	35.87	8.03	4.55	Used for coking test No. 35.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (wet).	Large coke.	Medium coke.	Total coke made.	Breeze and ash	Per cent of yield.			
									Large.	Medium.	Total.	Breeze and ash.
			<i>Hours.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>				
35 (washed)	Nov. 8, 2 p. m.	Nov. 10, 9 a. m.	43	8,000	865	2,471	3,336	535	10.8	30.9	41.7	7.3

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
35....	13.1	22.42	49.78	85.19	43	57	Lbs. 165	Feet. 66	2.8	1.88	1399	P. ct. 5.73	P. ct. 1.87	P. ct. 75.49	P. ct. 16.91	P. ct. 4.57	P. ct. 0.018

This coal made a brittle, fine-fingered coke, in small pieces, which broke up easily, although they were hard. The cell structure was high and the ash and sulphur very high, which would exclude any of this coke from metallurgical use.

IOWA No. 4.

Coking test No. 34.—Lump coal from mine No. 3, Centerville Block Coal Company, Centerville, Iowa.

The coke produced in this test was of the same general character as that obtained from Iowa No. 3, except that it was not quite so high in either sulphur or ash. The charge consisted of 8,000 pounds of washed coal (p. 1470), which was burned for 40 hours, producing 3,722 pounds of coke and 426 pounds of breeze and ash.

Analysis of Iowa No. 4 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Washed.....	1378	17.80	37.59	37.39	7.14	3.59	Used for coking test No. 34.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (wet).	Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
									Large.	Medium.	Total.	Breeze and ash.
			Hours.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.				
34 (washed) ...	Nov. 7, 5 p. m. ...	Nov. 9, 9 a. m. ...	40	8,000	1,114	2,608	3,722	426	13.9	32.6	46.5	5.3

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
							Lbs.	Feet.				P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
34....	12.6	21.6	47.88	82.08	45	55	160	64	2.6	1.82	1400	13.05	2.32	73.10	11.53	2.97	0.013

The coke from this coal showed the same structure as the other Iowa cokes. It was fine fingered, very brittle, and broke up into small pieces. The cell structure was high, ash and phosphorus normal, but sulphur very high. Lead and zinc works could use it, but it is not very desirable even for them on account of the small size of the coke.

IOWA NO. 5.

Coking test No. 40.—Run-of-mine coal from Inland mine No. 1, Inland Fuel Company, Chariton, Iowa.

The result of this test, made on 9,000 pounds of washed coal (p. 1470), and burned for 66 hours, was a mixture of unburned coal, charred coke, and ash.

Analysis of Iowa No. 5 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Washed	1419	19.25	31.07	41.75	7.93	2.28	Used for coking test No. 40.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (wet).	Remarks.
			Hours.	Pounds.	
40 (washed)	Nov. 14, 3 p. m. . .	Nov. 17, 9 a. m. . .	66	9,000	No coke.

Though this washed coal started off very well in a hot oven, all that was gotten out of it was unburned coal mixed with pieces of charred coal and ashes. There was no sign of fusing and the coal was manifestly noncoking.

All of the Iowa coals tested are too high in sulphur to produce blast-furnace coke, and as the sulphur occurs largely as gypsum it can not be removed by washing. The ash is also high in relation to the fixed carbon.

KANSAS No. 1.

Coking test No. 3.—Run-of-mine coal from mine No. 10, Western Coal and Mining Company, Fleming, Kans.

In making this test a charge of 7,100 pounds was used, and this was burned for 120 hours. At the end of the period the charge was found to be sintered on top, while under this sintering was a thin layer of light coke, with the remainder of the coal in the oven uncoked or partly burned.

Analysis of Kansas No. 1 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed	1094	8.10	31.26	45.82	14.84	4.48	Used in coking test No. 3.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Remarks.
			Hours.	Pounds.	
3 (unwashed)	Sept. 17, 8 a. m.	Sept. 22, 8 a. m.	120	7,100	No coke.

The results were the same as in the tests with other Kansas coals. The coal lay dead in the oven and after 5 days with repeated wood charges on top the effort to coke it was abandoned. Some coke was produced, in pieces about 12 inches long, but it was soft and spongy, with large cells. The lower part of the charge was all uncoked coal, charred. Ash and sulphur are high in the coal. The ash may be reduced by washing, but the sulphur, which occurs as gypsum, can not be removed either by washing or burning. Laboratory tests conformed with coking results, as the coal was shown to be slightly coking.

The washing plant was not finished at the time this test was made, so it was not possible to get any washed coal for a test.

KANSAS No. 2.

Coking test No. 2.—Lump, nut, and slack coal from mine No. 11, Western Coal and Mining Company, Yale, Kans.

The behavior of this coal in the oven was similar to that of Kansas No. 1. It showed no tendency to coke, although the charge of 9,125 pounds was burned for 159 hours.

Analysis of Kansas No. 2 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Unwashed.....	1087	3.96	30.46	45.54	20.04	5.59	Used in coking test No. 2.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Remarks.
			<i>Hours.</i>	<i>Pounds.</i>	
2 (unwashed).....	Sept. 13, 5 p. m....	Sept. 20, 8 a. m....	159	9,125	No valuable coke.

This coal started off well and kept up combustion for some time, when it died out and the coal lay dead in the oven. It would not burn, though helped along with wood placed on top of the charge. When drawn, it showed a hard scum on top, with a thin layer of coke next to it, finishing up with charred and raw coal at the bottom of the oven.

KANSAS No. 3.

Coking test No. 1.—Run-of-mine coal from mine No. 9, Southern Coal and Mercantile Company, Scammon, Kans.

This charge consisted of 11,300 pounds of unwashed coal, which was burned for 96 hours. It coked for about 12 inches from the top, while the remainder was simply charred coal and ash.

Analysis of Kansas No. 3 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1074	1.75	32.95	48.39	16.91	5.60	Used in coking test No. 1.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).
			Hours.	Pounds.
1 (unwashed).....	Sept. 9, 8 a. m.....	Sept. 13, 8 a. m....	96	11,300

The coking charge started off well and after 4 days was drawn, as coking appeared to be finished. It was then found that the coking process had extended only from 4 to 6 inches from the top, forming a glazed covering with some cracks; under this was a spongy coke with a structure much honeycombed, as if inflated by bubbles of gas. Below this was uncoked coal, partly charred. The large percentage of ash was clearly noticeable by the slate and brownish lumps intermixed with the honeycombed structure. It is apparent that this coal will not fuse sufficiently to produce coke. The high sulphur, mostly in the shape of gypsum, can not be removed either by washing or burning, though the high percentage of ash could be reduced somewhat by washing.

KANSAS NO. 4.

Coking test No. 43.—Lump coal from Atchison Coal Mining Company, Atchison, Kans.

This coal showed more of a tendency to coke than any of the other coals from Kansas. The charge, consisting of 10,000 pounds, was burned for 67 hours. It yielded 5,213 pounds of hard but brittle coke and 432 pounds of breeze and ash. The coke is, however, too high in sulphur (6.15 per cent) for use in an iron furnace, but it may be used in lead and zinc smelters, for which purpose a high percentage of sulphur is not detrimental.

Analysis of Kansas No. 4 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1443	6.63	36.99	43.45	12.93	7.19	Used in coking test No. 43.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
									Large.	Medium.	Total.	Breeze and ash.
43 (unwashed).	Nov. 18, 2 p. m.	Nov. 21, 9 a. m.	Hours. 67	Lbs. 10,000	Lbs. 3,642	Lbs. 1,571	Lbs. 5,213	Lbs. 432	36.4	15.7	52.1	4.3

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Coke.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
43.....	13.30	21.48	50.54	81.62	50	50	Lbs. 187	Feet. 75	2.5	1.92	1455	P. ct. 0.52	P. ct. 1.68	P. ct. 79.82	P. ct. 17.98	P. ct. 6.15	P. ct. 0.0148

This coal produced a hard coke of good cell structure, capable of carrying a burden, but high in ash, and the exceedingly high sulphur makes it unfit for blast-furnace or foundry purposes, though lead and zinc works could use it, providing the ash can be reduced by washing.

KENTUCKY No. 1.

Coking test No. 44.—Run-of-mine coal from Straight Creek mine No. 2 of the National Coal and Iron Company, Straight Creek, Ky.

This test was made on 10,000 pounds of unwashed coal burned for 66 hours. It produced 5,441 pounds of hard coke, which was fine fingered and easily broken into small pieces. The breeze and ash weighed 355 pounds.

Analysis of Kentucky No. 1 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1448	2.71	37.22	56.17	3.90	1.23	Used for coking test No. 44.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
									Large.	Medium.	Total.	Breeze and ash.
44 (unwashed).	Nov. 19, 3 p. m.	Nov. 22, 9 a. m.	Hours. 66	Lbs. 10,000	Lbs. 3,953	Lbs. 1,480	Lbs. 5,441	Lbs. 355	39.5	14.8	54.4	3.5

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
44.....	13.2	21.38	50.16	81.24	50	50	Lbs. 167	Feet. 67	2.8	1.83	1458	P. ct. 1.48	P. ct. 0.83	P. ct. 92.34	P. ct. 5.35	P. ct. 0.84	P. ct. 0.036

This coal made a good coke, which, though small fingered, like most of the Kentucky coke, has good cell structure, but the hardness and burden-bearing qualities are not up to standard. Ash and sulphur are much below the best Connellsville coke, but the phosphorus is a little higher. The color and ring are good and the coke will make a good metallurgical fuel.

KENTUCKY No. 2.

Coking test No. 42.—Lump, nut, pea, and slack coal from mine No. 11 of the St. Bernard Mining Company, Earlington, Ky.

This test was made on 9,000 pounds of unwashed coal. It was burned for 42 hours, but showed no tendency to coke.

Analysis of Kentucky No. 2 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed	1438	8.66	32.45	41.13	17.76	4.04	Used in coking test No. 42.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Remarks.
			Hours.	Pounds.	
42 (unwashed).....	Nov. 17, 3 p. m....	Nov. 19, 9 a. m....	42	9,000	No coke.

This coal produced only burned ashes mixed with some raw coal, with no sign of fusing. The moisture, ash, and sulphur in the coal were excessive.

KENTUCKY No. 3.

Coking test No. 47.—Run-of-mine coal from Barnsley mine of St. Bernard Mining Company, Earlington, Ky.

In this test the charge consisted of 10,000 pounds of washed coal (p. 1470), burned for 66 hours. It produced a coke of fair quality, of good color and ring, but somewhat high in sulphur. It produced 5,433 pounds of coke and 426 pounds of breeze and ash.

Analysis of Kentucky No. 3 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Washed.....	1466	10.51	37.33	44.76	7.40	2.51	Used in coking test No. 47.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (wet).	Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
									Large.	Medium.	Total.	Breeze and ash.
			Hours.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.				
47 (washed)...	Nov. 23, 3 p. m....	Nov. 26, 9 a. m....	66	10,000	3,953	1,480	5,433	426	39.5	14.8	54.3	4.2

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
47....	12.8	22.7	48.64	86.26	44	56	Lbs. 190	Feet. 76	2.4	1.81	1484	P. ct. 0.14	P. ct. 0.56	P. ct. 86.31	P. ct. 12.99	P. ct. 2.16	P. ct. 0.0094

This coal made a good-sized coke with a medium ring and of good color. The cell structure was rather high and the coke soft, though it will carry a burden. Phosphorus was low, the ash above standard, and the sulphur very high, making it undesirable for blast-furnace fuel.

KENTUCKY No. 4.

Coking test No. 46.—Run-of-mine coal from Wheatcroft Coal and Mining Company, Wheatcroft, Ky.

This test was also made on 10,000 pounds washed coal (p. 1471), which was burned for 66 hours, and yielded 5,558 pounds of coke and 313 pounds of breeze and ash. The coke was of good color and ring, but, like Kentucky No. 4, was too high in sulphur for blast-furnace use.

Analysis of Kentucky No. 4 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Washed.....	1459	6.18	39.07	48.70	6.05	2.74	Used in coking test No. 46.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (wet).	Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
									Large.	Medium.	Total.	Breeze and ash.
			<i>Hours.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>				
46 (washed) ...	Nov. 22, 2 p. m....	Nov. 25, 8 a. m...	66	10,000	3,674	1,854	5,528	313	36.7	18.5	55.2	3.1

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
							<i>Lbs.</i>	<i>Feet.</i>				<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>
46....	14.4	22.42	54.72	85.19	51	49	207	83	2.9	1.84	1475	0.52	0.63	86.50	12.35	2.37	0.015

The coal produced a fair coke, of good color and ring; stood handling fairly well. The coke was hard, of good cell structure, and capable of carrying a high burden. It was also low in phosphorus. The ash might be a little lower, and its

amount could be reduced by thorough washing, which could not be accomplished at the testing plant because of the small amount of coal available for washing. The only detriment to this coke appears to be in the high sulphur, which, unless eliminated, will prevent its use in blast furnaces.

MISSOURI No. 2.

Coking test No. 26.—Run-of-mine coal from mine No. 8 of the Northwestern Coal and Mining Company, Bevier, Mo.

This charge consisted of 12,000 pounds washed coal (p. 1471), which was coked for 87 hours. It yielded 5,040 pounds of long-fingered brittle coke, having large pieces of slate mixed through it. The breeze and ash amounted to 580 pounds. The coke is high in both sulphur and ash.

Analysis of Missouri No. 2 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Washed.....	1304	14.14	35.53	42.57	7.76	3.26	Used in coking test No. 26.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Per cent of yield.						
				Coal charged (wet).	Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Large.	Medium.
			Hours.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.		Total.
26 (washed) . . .	Oct. 25, 5 p. m. . .	Oct. 29, 8 a. m. . .	87	12,000	1,721	3,319	5,040	580	14.3	27.6
									42.0	4.8

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.						
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.	
26	11.75	20.26	44.65	76.98	48	52	Lbs. 207	Feet. 83	2.3	1.86	1325	P. ct. 3.45	P. ct. 1.80	P. ct. 80.27	P. ct. 14.48	P. ct. 2.79	P. ct. 0.02	

This charge produced long-fingered coke, very brittle, and though the coal was washed large pieces of slate mixed with charred coal were observed, indicating that the washing was faulty. The cell structure was high. The coke might have

been harder, though its burden-bearing qualities were excellent. The ash and sulphur were both high and they make this coke undesirable for blast-furnace use, though it will do very well for lead or zinc smelting works.

MISSOURI No. 3.

Coking test No. 56.—Slack coal from Mendota Coal and Mining Company, Mendota, Mo.

This coal showed no tendency whatsoever to coke, although it was washed (p. 1465) and burned for 42 hours.

Analysis of Missouri No. 3 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Washed.....	1528	24.15	33.10	35.51	7.24	2.74	Used in coking test No. 56.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (wet).	Remarks.
			<i>Hours.</i>	<i>Pounds.</i>	
56 (washed).....	Dec. 6, 4 p. m.....	Dec. 8, 9 a. m.....	41	9,000	No coke.

This coal would not coke. The product was some charred coal, mixed with ashes.

MISSOURI No. 4.

Coking test No. 54.—Run-of-mine coal from Morgan County Coal Company, near Barnett, Mo.

This coal produced a coke of fair grade, of a gray color, and of a good metallic ring. The charge was 11,000 pounds of unwashed coal, and yielded 4,905 pounds of coke and 128 pounds of breeze and ash. The coke, however, is too high in sulphur for blast-furnace use, but it is believed that the quality of this coke could be improved by washing the coal before charging into the ovens.

Analysis of Missouri No. 4 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Unwashed	1513	12.04	41.35	41.34	5.27	5.14	Used in coking test No. 54.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven. Hours.	Coal charged (dry.) Lbs.	Large coke. Lbs.	Medium coke. Lbs.	Total coke made. Lbs.	Per cent of yield.			
								Breeze and ash. Lbs.	Large. Lbs.	Medium. Lbs.	Total. Lbs.
54 (unwashed).	Dec. 3, 3 p. m.	Dec. 6, 8 a. m.	65	11,000	3,838	1,067	4,905	128	34.9	9.7	44.6
											1.17

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.				
	Dry.	Wet.	Dry.	Wet.	Coke.	Colla.						Moisture.	Volatle matter.	Fixed carbon.	Ash.	Sulphur.
							Lbs.	Feet.				P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
54....	12.5	17.55	47.50	66.60	63	37	87	35	2.6	1.83	1519	2.51	1.11	85.57	10.81	4.60
																0.018

While this coal yielded a fair grade of coke, it was with exceedingly low cell structure and low burden-bearing qualities. The ash and phosphorus are of standard proportions, but sulphur is unusually high, making this coke fit only for lead or zinc works. Washing might improve it some, but can not reduce the sulphur sufficiently to produce a high-grade metallurgical fuel.

WEST VIRGINIA NO. 1.

Coking test No. 14.—Run-of-mine coal, Virginia and Pittsburg Coal Company, Kingmont, W. Va.

This test was made on 9,000 pounds of unwashed coal. The charge was burned for 64 hours and yielded 5,572 pounds of coke and 268 pounds of breeze and ash. The coke was of good quality, but somewhat brittle.

Analysis of West Virginia No. 1 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatle matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed	1205	1.93	36.50	54.97	6.60	0.88	Used in coking test No. 14.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
									Large.	Medium.	Total.	Breeze and ash.
			Hours.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.				
14 (unwashed).	Oct. 8, 4 p. m.....	Oct. 11, 8 a. m....	64	9,000	2,847	2,725	5,572	268	31.6	30.3	61.9	2.98

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
14....	12.3	21.14	46.74	80.33	47	53	Lbs. 164	Feet. 63	2.5	1.84	1248	P. ct. 0.40	P. ct. 1.95	P. ct. 87.47	P. ct. 10.18	P. ct. 0.71	P. ct. 0.029

This coal produced a good coke, the only detriment appearing to be in its brittleness, the coke breaking up into small pieces with repeated handling. This was observed under the same conditions which will obtain when loading and unloading cars and getting the coke into the furnace. Otherwise it compares well with standard Connellsville coke, as the ash and sulphur are lower, with phosphorus and the cell structure about the same. The hardness of the coke is below that of Connellsville and so are the burden-bearing qualities. As other West Virginia coal showed an improvement in this respect when washed, we may assume that hardness and burden-bearing qualities of this coal would be increased by washing. It will do for blast furnaces, cupolas, and for all metallurgical purposes in which coke is used as a fuel.

WEST VIRGINIA NO. 2.

Coking tests Nos. 15 and 16.—Run-of-mine coal from Pitcairn mine of the Pitcairn Coal Company, Clarksburg, W. Va.

Two tests were made of this coal, unwashed and washed. The first charge was 9,000 pounds of unwashed coal, producing 5,235 pounds of gray coke, somewhat brittle and high in sulphur and ash. The washed coal (p. 1471), of which 13,000 pounds was charged, showed an improvement in the coke, though the sulphur was still too high for blast-furnace use. The yield from the second charge was 7,808 pounds, or 60 per cent, as compared with 58.2 per cent from the unwashed coal.

Analysis of West Virginia No. 2 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed	1218	1.73	39.20	50.85	8.22	3.38	Used in coking test No. 15.
Washed.....	1217	3.98	39.76	49.21	7.05	2.84	Used in coking test No. 16.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged.		Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
				Wet.	Dry.					Large.	Medium.	Total.	Breeze and ash.
			Hrs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.				
15 (unwashed).	Oct. 11, 8 a. m.	Oct. 13, 10 a. m.	50	.....	9,000	3,020	2,215	5,235	286	33.5	24.6	58.1	3.5
16 (washed)...	Oct. 11, 5 p. m.	Oct. 14, 9 a. m.	64	13,000	.....	4,593	3,315	7,908	302	35.3	25.5	60.8	2.3

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.						
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.	
15....	14.13	21.98	53.34	83.52	52	48	Lbs. 187	Feet. 75	2.5	1.94	1246	P. ct. 0.42	P. ct. 0.68	P. ct. 83.95	P. ct. 14.95	P. ct. 3.40	P. ct. 0.023	
16....	18.9	25.77	71.82	97.92	58	42	240	96	3.1	1.89	1247	.50	1.31	86.70	11.40	2.24	.017	

The coke produced from this coal would be satisfactory if it were not so high in ash and sulphur, which unfits it for blast-furnace use. There is a marked improvement in the coke after the coal was washed, and as only small quantities were available to run through the washer, it was not to be expected that the proper working results could be obtained. The coke from the washed coal was very hard and had good burden-bearing qualities and low phosphorus. The cell structure is somewhat below that of the Connellsville coke, which makes the coke very heavy. It is brittle, and repeated handling caused it to break up into small pieces.

WEST VIRGINIA NO. 3.

Coking tests Nos. 17 and 18.—Run-of-mine coal from West Virginia Coal Company, Richard, W. Va.

Two tests, one of unwashed and one of washed coal, were made on this sample. The charge of unwashed coal weighed 9,000 pounds and was coked 41 hours. It

yielded 5,929 pounds of coke of gray color, brittle and somewhat high in ash, and 364 pounds of breeze and ash. The washed charge (p. 1472) weighed 14,000 pounds, was coked for 66 hours, and yielded 9,070 pounds of coke of the same character as noted above and 535 pounds of ash and breeze. The quality of the coke was not improved by washing, except by a small reduction in the amount of ash.

The first test of 41 hours' duration gave a yield of 65.9 per cent, the second test of 66 hours gave a yield of 64.8 per cent.

Analysis of West Virginia No. 3 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1230	2.25	30.60	57.40	9.75	0.99	Used in coking test No. 17.
Washed.....	1249	4.11	29.54	57.34	9.01	1.18	Used in coking test No. 18.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.		Coal charged.		Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.							
			Hrs.	Lbs.	Lbs.	Lbs.					Lbs.	Lbs.	Lbs.	Lbs.	Large.	Medium.	Total.	Breeze and ash.
17 (unwashed)	Oct. 13, 4 p. m.	Oct. 15, 9 a. m.	41	9,000	3,618	2,311	5,929	364	40.2	25.6	65.8	4.0						
18 (washed)...	Oct. 14, 3 p. m.	Oct. 17, 9 a. m.	66	14,000	6,042	3,028	9,070	535	43.1	21.6	64.7	3.8						

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength.)	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
17....	16.2	23.56	61.56	89.52	54	46	200	80	2.9	1.95	1254	P. ct. 0.22	P. ct. 0.83	P. ct. 80.77	P. ct. 18.18	P. ct. 0.93	P. ct. 0.065
18....	14.76	22.94	56.08	87.17	50	50	260	104	2.8	1.94	1259	.38	.87	84.48	14.27	1.19	.079

The coke from the unwashed coal gave a gray brittle coke that had no ring. The sulphur was fair, but the ash and phosphorus were high. An improvement could be observed in the coke made from the washed coal, as it showed a marked reduction in ash. This coke was of good color and ring, and with some experiments in washing there appears to be no reason why this coal should not make a good coke. The small amount of coal run through the washer at the testing plant was not enough to adapt it to this special coal, as the results show. The cell

structure and burden-bearing qualities had been increased by washing, and the coke itself was less brittle, making it well adapted for blast furnaces, providing the high phosphorus, which is three times that of the Connellsville coke, is not detrimental. It would do better in a cupola, where a liquid iron is desirable.

WEST VIRGINIA NO. 4.

Coking tests Nos. 19 and 20.—Run-of-mine coal from West Virginia Coal Company, Bretz, W. Va.

This coal was tested washed and unwashed. The unwashed charge contained 12,000 pounds. It was burned for 65 hours and yielded 8,907 pounds, or 74.2 per cent of coke, and 428 pounds of breeze and ash. The charge of washed coal (p. 1472) weighed 9,000 pounds. It was coked for 42 hours and yielded 6,367 pounds, or 70.7 per cent, of coke, and 374 pounds of breeze and ash. The coke obtained was of good color, but was somewhat impaired by cross fractures. No improvement was noticed as a result of washing.

Analysis of West Virginia No. 4 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1253	2.72	27.62	59.16	10.50	0.86	Used in coking test No. 19.
Washed.....	1260	3.47	27.95	61.05	7.53	.74	Used in coking test No. 20.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged.		Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
				Wet.	Dry.					Large.	Medium.	Total.	Breeze and ash.
19 (unwashed)	Oct. 15, 4 p. m.	Oct. 18, 9 a. m.	Hrs. 65	Lbs.	Lbs. 12,000	Lbs. 5,285	Lbs. 3,622	Lbs. 8,907	Lbs. 428	44.0	30.1	74.2	3.5
20 (washed)...	Oct. 17, 3 p. m.	Oct. 19, 9 a. m.	42	9,000	.....	3,654	2,713	6,367	374	40.6	30.1	70.7	4.1

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
19....	14.45	22.14	54.91	84.13	53	47	Lbs. 230	Feet. 92	2.6	1.84	1265	P. ct. 0.62	P. ct. 1.43	P. ct. 86.10	P. ct. 11.85	P. ct. 0.82	P. ct. 0.031
20....	13.7	22.54	52.06	85.65	46	54	210	84	2.7	1.94	1273	.20	1.15	85.42	13.23	.69	.019

A gray coke in large pieces was produced from the unwashed coal. It had no ring, but the ash and sulphur compared well with that of Connellsville coke. It was not quite so hard, but had good burden-bearing qualities. The cell structure is a little high. Washing did not seem to improve it materially, as the ash was higher, though the sulphur was lower, showing that the washing was not perfect. The cell structure and hardness were increased, yielding a good coke of fair color and ring. It was brittle with cross fractures, which increases the amount of small coke in the repeated handling which is necessary in loading and unloading cars to get the coke into the blast furnace. Properly washed, this will make a good metallurgical coke, adapted for all purposes where coke is used as a fuel.

WEST VIRGINIA No. 5.

Coking tests Nos. 23, 24, and 25.—Lump and nut coal from Davis Colliery Company, Coalton, W. Va.

Three coking tests were made on this shipment—one of unwashed and one of washed run of mine, crushed before coking to 1½ inches in diameter, and one of pulverized coal washed in the New Century jig (pp. 1472–1473). The first charge of unwashed coal, weighing 13,000 pounds, was burned for 64 hours and yielded 8,298 pounds, or 63.8 per cent, of coke and 497 pounds of ash and breeze. The washed charge, weighing 13,000 pounds, was burned 66 hours. It yielded 7,163 pounds, or 55.1 per cent, of coke and 461 pounds of ash and breeze. The pulverized coal, weighing 10,000 pounds, was burned 69 hours and yielded 4,256 pounds, or 42.56 per cent, of coke and 229 pounds of ash and breeze. The results showed that the coal would make a good coke if the ash could be materially reduced. Washing in this case lowered the percentage of ash in the coke from 19.14 per cent in the first test to 14.81 per cent in the second and 15.98 per cent in the third. The results of these tests show that the washing of this coal for coking purposes is advisable.

Analysis of West Virginia No. 5 coal.

Character of coal.	Chemical labora- tory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Unwashed.....	1283	2.43	28.30	58.55	10.72	0.90	Used in coking test No. 23.
Washed.....	1287	4.84	28.12	56.76	10.28	.91	Used in coking test No. 24.
Washed in jig.....	1301	19.50	23.76	48.55	8.19	.79	Used in coking test No. 25.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged.		Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
				Wet.	Dry.					Large.	Medium.	Total.	Breeze and ash.
			Hrs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.				
23 (unwashed)	Oct. 21, 5 p. m.	Oct. 24, 9 a. m.	64	.....	13,000	6,140	2,158	8,298	497	47.2	16.6	63.8	3.8
24 (washed) ...	Oct. 22, 3 p. m.	Oct. 25, 9 a. m.	66	13,000	.....	4,269	2,894	7,163	461	32.8	22.2	55.1	3.5
25 (jig washed)	Oct. 25, 12 m.	Oct. 28, 9 a. m.	69	10,000	.....	3,136	1,120	4,256	229	38.9	13.9	52.8	2.8

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.	Cells.	Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.								Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
							Lbs.	Feet.				P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
23....	18.6	23.97	70.68	91.08	61	39	420	168	3.1	1.90	1302	2.60	1.12	77.14	19.14	0.77	0.067
24....	16.0	23.20	60.80	88.16	56	44	375	150	2.7	1.89	1303	.42	.43	84.34	14.81	.83	.066
25....	15.23	22.75	57.87	84.15	54	46	390	156	2.7	1.89	1317	.27	.78	82.97	15.90	.82	.087

The condition of this coal promised a good coke, except for the presence of slate, which was noticed in the coal and was more evident in the coke. Consequently the ash was high in the latter. Sulphur was low, as was the cell structure, and the burden-bearing qualities of this coke were high. The phosphorus was three times that of standard coke. The improvement by washing showed increased cell structure and a reduction of ash. The hardness and burden-bearing qualities were decreased, the sulphur remaining about the same, but phosphorus higher. This suggested the making of another test, when the coal was crushed fine and washed in the jig washer. The result did not differ materially from that of the second test. The coke was very dense, of grayish color, without ring, and invariably high in ash. It stood handling well, and on account of its low sulphur may be used as a metallurgical fuel, providing the ash is reduced, as it undoubtedly can be by careful washing.

WEST VIRGINIA NO. 6.

Coking tests Nos. 27, 30, and 33.—Run-of-mine coal from the New River Smokeless Coal Company, Rush Run, W. Va.

Three tests were made on this coal, which was unwashed. The first charge, consisting of 13,000 pounds, was burned for 90 hours, and yielded 8,303 pounds, or 63.9 per cent, of light-gray, soft coke. The second charge, which consisted of

9,000 pounds, was burned for 66 hours, and yielded 6,399 pounds, or 71.1 per cent, of coke of somewhat better quality than the first, although still gray and light. The third charge consisted of 8,000 pounds of pulverized coal. It was burned for 44 hours, and yielded 5,849 pounds, or 73.1 per cent, of coke, which was dense and tough, but light in weight and color, and of poor ring.

Analysis of West Virginia No. 6 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1316	1.76	21.48	71.92	4.84	0.55	Used in coking test No. 27.
Do.....	1344	2.27	22.03	70.30	5.40	.88	Used in coking test No. 30.
Unwashed, fine.....	1373	1.73	21.12	71.57	5.58	.64	Used in coking test No. 33.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Per cent of yield.							
					Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Large.	Medium.	Total	Breeze and ash.
			Hours.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.				
27 (unwashed).	Oct. 28, 2 p. m....	Nov. 1, 8 a. m....	90	13,000	5,285	3,018	8,303	381	40.7	23.2	63.9	2.9
30 (unwashed).	Nov. 2, 2 p. m....	Nov. 5, 8 a. m....	66	9,000	4,161	2,238	6,399	382	46.2	24.9	71.1	4.2
33 (unwashed).	Nov. 5, 5 p. m....	Nov. 7, 1 p. m....	44	8,000	3,832	2,017	5,849	273	47.9	25.2	73.1	3.4

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.						
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.		Fixed carbon.	Ash.	Sulphur.	Phosphorus.
							Lbs.	Feet.				P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	
27....	10.46	19.46	39.75	74.94	45	55	187	75	2.2	1.77	1336	2.83	2.17	89.84	5.16	0.69	0.008	
30....	13.2	22.04	50.16	83.75	45	55	200	80	2.7	1.87	1370	.36	1.34	93.04	5.26	.76	.007	
33....	12.5	22.14	47.50	84.13	41	59	215	85	2.7	1.79	1379	1.89	1.83	88.80	7.48	.69	.006	

The coke made from the run-of-mine coal showed a very low ash and low sulphur and phosphorus, but it was gray, soft, and rather light. The cell structure was above standard; the burden-bearing qualities and hardness were lower than desirable. This suggested crushing the coal for a second test, which increased its hardness and enabled it to carry a heavier burden. Though the cell structure remained the same, the color was improved and the coke was heavier. Ash,

sulphur, and phosphorus were about the same as before. A third test was made with powdered coal in which the results did not differ very much from the previous ones, except that the coke seemed denser, was darker, and had a poor ring. The ash was somewhat higher. Sulphur and phosphorus the same as before, as was also hardness, but burden-bearing qualities were increased. As this coal is low in volatile matter it is recommended that it be mixed with others higher in volatile matter; that it be coked in a retort oven, where a coke can be produced which will possess all the qualities of a standard coke and will be much superior to it on account of its low ash, sulphur, and phosphorus.

WEST VIRGINIA No. 7.

Coking test No. 37.—Run-of-mine coal from the New River Smokeless Coal Company, Sun, W. Va.

This test was made on unwashed coal, the charge weighing 8,000 pounds. It produced 5,119 pounds, or 64 per cent, of coke of good size and quality, but rather dark in color.

Analysis of West Virginia No. 7 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Unwashed.....	1398	3.85	20.55	70.58	5.02	1.36	Used in coking test No. 37.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
									Large.	Medium.	Total.	Breeze and ash.
37 (unwashed).	Nov. 10, 1 p. m....	Nov. 12, 9 a. m....	<i>Hours.</i> 44	<i>Lbs.</i> 8,000	<i>Lbs.</i> 3,478	<i>Lbs.</i> 1,641	<i>Lbs.</i> 5,119	<i>Lbs.</i> 287	43.4	20.5	63.9	3.6

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic foot.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
27....	10.3	19.46	39.14	73.94	44	56	<i>Lbs.</i> 225	<i>Feet.</i> 90	2.4	1.80	1414	<i>P. ct.</i> 0.67	<i>P. ct.</i> 1.23	<i>P. ct.</i> 90.40	<i>P. ct.</i> 7.70	<i>P. ct.</i> 1.03	<i>P. ct.</i> 0.0061

A good-sized coke, having all the appearance of a good fuel, was produced. Ash, sulphur, and phosphorus show up well, though the coke is softer than standard Connellsville coke, and its cell structure rather high. It has good burden-bearing qualities, but breaks up into small pieces with repeated handling.

WEST VIRGINIA No. 8.

Coking test No. 38.—Run-of-mine coal from Gauley Mountain Coal Company, Ansted, W. Va.

This test was made on 11,000 pounds of unwashed coal, which was burned for 66 hours and yielded 7,124 pounds, or 64.7 per cent, of coke, and 589 pounds of ash and breeze. The coke was hard, of good color, although of somewhat irregular cell structure.

Analysis of West Virginia No. 8 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Unwashed.....	1406	3.82	31.77	57.21	7.20	0.89	Used in coking test No. 38.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
									Large.	Medium.	Total.	Breeze and ash.
			<i>Hours.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>				
38 (unwashed).	Nov. 11, 3 p. m.	Nov. 14, 9 a. m.	66	11,000	4,514	2,610	7,124	589	41.0	23.7	64.7	5.3

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
							<i>Lbs.</i>	<i>Feet.</i>				<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>
38....	16.2	23.89	61.56	90.78	53	47	200	8.0	3.0	1.92	1418	2.79	0.53	82.87	14.31	0.77	0.0116

The coke made of this coal would be considered very fine if it did not show cross fractures which tend to make it brittle. It has a good color and a metallic ring, and is low in sulphur and phosphorus, though the ash is somewhat high. It is hard and will carry a good burden. The cell structure is irregular and by repeated handling the coke broke up into small pieces. The coal showed a large amount of slate, appearing again as ash in the coke, which could be reduced by washing.

WEST VIRGINIA NO. 9.

Coking tests Nos. 50 and 53.—Run-of-mine coal from Vulcan mine of the Mount Carbon Coal Company (Limited), Powellton, W. Va.

Two tests were made on this coal, the first being unwashed, the second washed. The unwashed charge weighed 10,000 pounds, and was burned 40 hours. It yielded 6,084 pounds, or 60.8 per cent, of coke, and 314 pounds of breeze and ash. The coke was heavy and grayish in color. It was of good quality, though slightly brittle. The coke from the washed coal (p. 1473) showed much improvement over that from the unwashed coal, and could be considered a high-grade coke. The charge of washed coal weighed 11,000 pounds, burned for 66 hours, and yielded 6,803 pounds, or 61.8 per cent, of coke, and only 78 pounds of ash and breeze.

Analysis of West Virginia No. 9 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1499	3.81	31.08	57.04	8.07	0.83	Used in coking test No. 50.
Washed.....	1510	5.74	32.14	57.61	4.51	.90	Used in coking test No. 53.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged.		Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
				Wet.	Dry.					Large.	Medium.	Total.	Breeze and ash.
50 (unwashed)	Nov. 28, 4 p. m.	Nov. 30, 9 a. m.	43	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.				
				8,000	3,980	2,095	6,084	314	49.8	26.2	76.0	3.9	
53 (washed)...	Dec. 2, 2 p. m.	Dec. 5, 8 a. m.	66	11,000	5,023	1,780	6,803	78	45.6	16.2	61.8	.7	

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
50....	18.8	23.68	71.44	89.98	64	36	Lbs. 227	Feet. 91	2.8	1.84	1503	P. ct. 0.29	P. ct. 2.41	P. ct. 88.15	P. ct. 9.15	P. ct. 0.82	P. ct. 0.0094
53....	15.1	22.46	57.38	85.34	55	45	360	145	2.9	1.87	1517	.27	.62	91.73	7.38	.77	.012

A heavy coke of gray color and slightly brittle was the product from this coal. In ash, sulphur, and phosphorus it is equal to the best Connellsville coke, with which it compares well in burden-bearing qualities, though it is slightly softer. The very low percentage of cells makes this coke very dense. By washing this coal the ash and sulphur showed a further reduction, the coke was harder, the cell structure was improved, and it will carry a heavier burden. The washed coal produced a coke which is much superior to that made from the unwashed coal and which stands rough handling well.

WEST VIRGINIA No. 10.

Coking test No. 39.—Lump and run-of-mine coal from Stuart M. Buck, Mora, W. Va.

This test was made on 11,000 pounds of unwashed coal. It was burned for 68 hours and yielded 7,858 pounds, or 71.4 per cent, of good, hard, heavy coke, slightly off color, and 429 pounds of ash and breeze.

Analysis of West Virginia No. 10 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1415	1.62	18.36	74.65	5.37	0.61	Used in coking test No. 39.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
									Large.	Medium.	Total.	Breeze and ash.
			Hours.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.				
Nov. 12, 1 p.m....		Nov. 15, 9 a.m....	68	11,000	5,631	2,227	7,858	429	51.2	20.2	71.4	3.9

Physical and chemical properties of coke.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
39....	14.7	22.55	55.86	85.69	52	48	Lbs. 287	Feet. 115	2.7	1.89	1428	P.ct. 3.68	P.ct. 0.53	P.ct. 87.54	P.ct. 8.25	P.ct. 0.56	P.ct. 0.007

The physical and chemical properties of this coke compare well with the best Connellsville coke, and in many respects indicate a coke that is better than that. It might be of better color and ring. Rough handling breaks it up.

WEST VIRGINIA NO. 11.

Coking test No. 41.—Run-of-mine coal from mines Nos. 1 and 2 of W. H. Coffman, Zenith, W. Va.

This was the only coal from West Virginia which did not coke in the ovens. The charge consisted of 11,000 pounds. It was burned for 67 hours, and when drawn consisted of ash mixed with raw, unburned coal.

Analysis of West Virginia No. 11 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Unwashed.....	1429	5.39	15.94	68.76	9.95	0.47	Used in coking test No. 41.

Coking test.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (dry).	Remarks.
			Hours.	Pounds.	
41 (unwashed).....	Nov. 15, 2 p. m.	Nov. 18, 9 a. m.	67	11,000	No coke.

The analysis of this coal did not show much difference from other West Virginia coals, and it started off well in the oven, but soon died out and lay dead. When the charge was drawn it showed that a hard crust was formed on top, the lower part was composed of sintered coke, the size of a man's fist, mixed with ashes and unburned coal. This coal washed showed the same results in the crucible. The coal proved to be noncoking.

WEST VIRGINIA NO. 12.

Coking tests Nos. 32 and 36.—Run-of-mine coal from Big Sandy Coal and Coke Company, Big Sandy, W. Va.

Two tests of this coal were made, the first being unwashed and the second washed. The unwashed charge was 11,000 pounds. It was burned for 68 hours and produced 7,082 pounds of coke, or 64.4 per cent, and 549 pounds of ash and breeze. The coke was of fair quality and had a metallic ring. It was of good color, but showed cross fractures. The washed charge (p. 1473) of the same coal weighed 8,000 pounds and was burned for 44 hours, producing 5,050 pounds, or 63.1 per cent, of coke and 583 pounds of ash and breeze. The coke was of large size and grayish color, but not particularly strong.

Analysis of West Virginia No. 12 coal.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Unwashed.....	1372	1.53	18.23	74.08	6.16	0.97	Used in coking test No. 32.
Washed.....	1394	8.36	18.20	68.54	4.90	1.11	Used in coking test No. 36.

Coking test and coke production.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged.		Large coke.	Medium coke.	Total coke made.	Breeze and ash.	Per cent of yield.			
				Wet.	Dry.					Large.	Medium.	Total.	Breeze and ash.
			Hrs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.				
32 (unwashed)	Nov. 5, 1 p. m. . .	Nov. 8, 9 a. m. . .	68	.....	11,000	5,065	2,017	7,082	549	46.1	18.3	64.4	5.0
36 (washed)...	Nov. 9, 1 p. m. . .	Nov. 11, 9 a. m. . .	44	8,000	.....	3,368	1,682	5,050	583	42.1	21.0	63.1	7.4

Physical and chemical properties of coke produced.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory number.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
32....	11.6	20.44	44.08	77.67	46	54	Lbs. 200	Feet. 80	2.5	1.95	1388	P. ct. 0.35	P. ct. 0.85	P. ct. 89.37	P. ct. 9.43	P. ct. 0.83	P. ct. 0.0077
36....	13.5	22.38	51.30	85.04	47	53	155	62	2.7	1.88	1407	5.16	.72	86.57	7.55	1.01	.01

The coke obtained from the unwashed coal was fair, of good color and ring, and the chemical analysis shows up well. It was not so hard as standard Connellsville coke, but would carry a good burden. Cell structure was above the standard. Ash and breeze were high.

By washing the coal larger pieces of coke were produced, but they were brittle, and the ash and breeze were higher. The amount of sulphur was increased, indicating that washing was not a success.

FOUNDRIY TESTS OF COKE.

By Dr. RICHARD MOLDENKE.

PERSONNEL.

In connection with the tests of the coals of the United States made at the plant of the United States Geological Survey, it was decided to make practical melting tests of those cokes which showed any likelihood of value to the foundry industry. It was proposed that these tests be made in the small model foundry connected with the St. Louis Exposition, and a committee on this matter was appointed by Dr. J. A. Holmes, the chief of the department of mines and metallurgy, under whose jurisdiction the foundry exhibits came. This committee consisted of Mr. Herbert E. Field, of Macintosh, Hemphill & Co., Pittsburg, Pa.; Mr. W. J. Fogarty, of the Magnetite Foundry Company, St. Louis, Mo., and Dr. Richard Moldenke, secretary of the American Foundrymen's Association, Watchung, N. J. The committee organized in St. Louis. The plan for the tests was drawn up by Mr. Field, while Doctor Moldenke arranged to come to the exposition for the actual tests, and to carry them out personally. This arrangement was subsequently carried out under the following plan of operations, based on a draft outlined by Mr. Field.

METHODS.

All materials were accurately weighed and charged. No estimating or measuring was done. The iron was of uniform composition and size. The scrap was made during the tests in pigs of uniform size. The same proportions were used for all tests, and the cupolas were charged in the same way for each test. The cupolas were put into the same condition daily, the tests were made consecutively, and the weather conditions were the same throughout the testing period. The pressure of the blast at the cupola was kept as constant as possible, many readings being taken during the tests.

RECORDS.

The records kept were as follows:

1. Identification of sample.
2. Charge in detail.
3. Time of putting on blast.
4. Time of first iron.
5. Time and weight of every ladle of melted iron.
6. Melting rate per hour.
7. Temperature of iron as measured by fluidity strips.
8. Melting loss.
9. Analysis and characteristics of coke.
10. Characteristics of test and conclusion.

SAMPLES OF COKE.

It is always difficult to get a fair sample of a coke to be analyzed unless great precautions are taken. For these tests four pieces were taken from different places in the oven, each piece extending from the top to the bottom. These large and representative pieces were sent to the laboratory for analysis. In this way the proper relation of carbon and slate was preserved, and the analysis would show much of value before the actual test was made, especially in regard to sulphur content.

CHEMICAL TESTS.

Determinations of the following constituents were called for:

1. Phosphorus.
2. Volatile carbon.
3. Fixed carbon.
4. Ash.
5. Moisture.
6. Total sulphur.
7. Sulphur in the ash.

As it is fairly certain that only the sulphur in the ash affects the iron, the last determination is of special value.

In addition to the above, the specific gravity of the coke and its strength under crushing strain were requested. Finally, the appearance was valued for the benefit of foundrymen who are not yet educated to the point of trying a coke on its merits irrespective of its appearance. Fixed values were given, based upon a maximum of 10 for the best of Connellsville foundry coke.

ESSENTIAL CONDITIONS OF TESTS.

CLASSES OF COKE.

Coke for foundry use must be studied from various standpoints. If the cupola is of a low-tuyère type, and long heats are taken off, a heavy coke is necessary to furnish sufficient fuel in small bulk to melt the metal and still hold the melting zone in proper position for economical work. Even should a light and strong coke hold the iron without crushing, it might not be possible to get enough of this coke in a low-tuyère cupola to melt the iron and retain the next charge at its proper height. On the other hand, a strong, light coke in a high-tuyère cupola is satisfactory and economical. It takes less coke to hold the iron at the proper melting zone, is more permeable to the blast, burns freer, and melts the iron faster than does heavy coke.

Cokes should therefore be divided into two classes and recommended according to their density, for high-tuyère or low-tuyère cupolas, as the coke is light or heavy. In these tests, as it was impossible to vary the height of the tuyères in the two small cupolas used, and as most of the cokes tried were light, a constant height of 14 inches above the lower tuyères was used (the upper tuyères being kept closed). This height was selected because previous running of the cupolas had indicated the necessity of a heavier bed than is usual in larger cupolas.

THE BLAST.

The question was also raised whether an average blast pressure should not be adopted, so that all the tests might be comparable. Heavy cokes can stand more blast pressure than light ones. While a large cupola might be run best with about 11 ounces for heavy cokes and 9 for the lighter varieties, the smaller cupolas can stand only about 9 ounces for the heavy cokes and 7 for the lighter ones. The blast pressure was, therefore, taken as near 7 ounces as it could be held for all the tests made.

MELTING RATIO.

The melting ratio was fixed at 1 to 7, this being regarded as a rather severe test for a coke in a small cupola. In charging the cupola, each of these being 24 inches inside the lining and practically identical so far as the details affecting the melting capacity were concerned, the fire was made up in the usual way, coke being added until the wood was burned out and the coke well ignited. Charging was then begun and completed. Before the first iron was thrown on the coke the height of the coke bed was measured with an iron rod having a flat weight attached. This height was brought up to proper level by the addition of coke, so that the tests might be comparable. A charge of 3,000 pounds of iron was selected for the tests, 430 pounds of coke (1 to 7) being used. Of the total iron charged, 2,250 pounds was pig iron and the other 750 was scrap, previously made. On the bed of coke,

the weight of which was subtracted from the total of 430 pounds used, a charge of four times as much metal was placed, this metal consisting of three-fourths pig and one-fourth scrap. The rest of the coke and the rest of the pig iron and scrap were next divided into four charges and placed in the cupola as usual.

It will thus be seen that the ratio of 1 to 7 was kept in all cases, but that the proportions of the charge would vary from test to test, depending upon the density of the coke. Thus a dense coke would have a comparatively heavy bed. This meant a heavy first charge on the bed and lighter charges above. With a light coke the bed would consume less of the 430 pounds allotted and less of the 3,000 pounds metal on this bed. The subsequent charges would then have comparatively more coke and metal.

GENERAL FEATURES.

As a matter of fact, the tests being on the cokes and not on the iron, blast, or any other item of foundry practice, all things had to be made constant, whether this absolutely suited the cokes or not. If, then, the results showed promise, even if not perfection, the coke could be recommended for further trial in the foundry. If nothing promising was noted the coke had to be condemned for foundry purposes, and if the results were not entirely satisfactory the owners of the coal could subsequently take up experiments with their coke and determine under just what conditions of foundry procedure their product would give the best results. They may find that with changes in the tuyère height from the standard one used in the tests better results would be obtained. They may further find that only additional washing of their coals is required to bring the composition of their cokes, otherwise not serviceable, within the list of foundry fuels. These questions being purely commercial necessarily had no standing in a series of comparative tests of materials actually made. It is left for the owners of the coals to find their own market after these tests have demonstrated the fitness of their coke for foundry purposes.

It should be added that, for purposes of comparison, tests were also made with well-known foundry cokes so that no question might arise as to the practicability of the system employed. These standard cokes were the well-known Frick Connellsville, the Milwaukee Semet-Solvay by-product coke, and the Gauley Mountain coke. The second series of tests to be made will have the same Connellsville coke and the Mount Carbon Company's Powellton coke, and perhaps several others, as standards for comparison.

The cupolas used were made by the Whiting Foundry Equipment Company and the J. S. McCormick Company. While the tests were under the direction of the writer, the foundry was in charge of Mr. A. E. Sauerwein, to whose faithful and enthusiastic services much of the success was due.

RESULTS OF THE TESTS.

The series of tables following give the results of the 19 tests made, and it is hoped that this interesting and most useful work may be continued for the benefit of the coal industry, which is seeking an enlarged field of distribution; and for the foundry industry, which desires a greater variety of cokes to draw from, with a reduction in freight expenses and more satisfactory service during the rush seasons.

Foundry test No. 18, on coke made from Alabama No. 1 coal (washed), December 1, 1904.

[Coke from Ivy Coal and Iron Company, Horsecrank, Ala.]

ANALYSIS OF COKE.

	Per cent.
Sulphur.....	0.69
Volatile carbon.....	.72
Fixed carbon.....	82.63
Ash.....	16.32
Phosphorus.....	.047
Moisture.....	.33
Specific gravity, 1.92.	
Appearance, 5 (Connellsville, 10).	

CHARGE.

[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke.....	220	54	52	52	52	430
Pig iron.....	660	398	398	398	396	2,250
Scrap.....	220	134	132	132	132	750

RECORD OF MELT.

Blast pressure averaged 6½ ounces.

Blast on, 11.14 a. m.

Iron running, 11.21 a. m.

Iron in 7 minutes.

	Pounds.
Ladle No. 1, 11.24 a. m.....	99
Ladle No. 2, 11.26 a. m.....	130
Ladle No. 3, 11.28 a. m.....	144
Ladle No. 4, 11.30 a. m.....	148
Ladle No. 5, 11.32 a. m.....	173
Ladle No. 6, 11.34 a. m.....	145
Ladle No. 7, 11.35 a. m.....	173
Ladle No. 8, 11.37 a. m.....	151
Ladle No. 9, 11.39 a. m.....	202
Ladle No. 10, 11.41 a. m.....	128
Ladle No. 11, 11.42 a. m.....	142
Ladle No. 12, 11.45 a. m.....	141
Ladle No. 13, 11.46 a. m.....	170

	Pounds.
Ladle No. 14, 11.47 a. m.	144
Ladle No. 15, 11.49 a. m.	116
Ladle No. 16, 11.51 a. m.	77
Total iron poured.	2,283
Rate (pounds per hour)	5,070
Iron recovered.	260
Coke recovered.	10

Melting loss, 15.2 per cent.

Fluidity strips ran up well. Iron hot. Heat very slow, but otherwise fair. Coke can be recommended for further trial.

Foundry test No. 17, on coke made from Kentucky No. 3 coal (washed), November 30, 1904.

[Coke from St. Bernard Mining Company, Earlington, Ky.]

	Per cent.
Sulphur.	2.16
Sulphur in ash.	.084
Volatile carbon.	.56
Fixed carbon.	86.31
Ash.	12.99
Phosphorus.	.0094
Moisture.	.14

Specific gravity, 1.81.

Appearance, 5 (Connellsville, 10).

CHARGE.

[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke.	180	64	62	62	62	430
Pig iron.	540	428	428	428	426	2,250
Scrap.	180	144	142	142	142	750

RECORD OF MELT.

Blast pressure averaged 6½ ounces.

Blast on, 3.10 p. m.

Iron running, 3.17 p. m.

Iron in 7 minutes.

	Pounds.
Ladle No. 1, 3.22 p. m.	80
Ladle No. 2, 3.26 p. m.	160
Ladle No. 3, 3.30 p. m.	255
Ladle No. 4, 3.32 p. m.	165
Ladle No. 5, 3.35 p. m.	265
Ladle No. 6, 3.37 p. m.	165

FOUNDRY TESTS OF COKE.

1373

	Pounds.
Ladle No. 7, 3.38 p. m.....	225
Ladle No. 8, 3.41 p. m.....	140
Ladle No. 9, 3.43 p. m.....	165
Total iron poured.....	1,620
Rate (pounds per hour).....	4,630
Iron recovered.....	916
Coke recovered.....	20

Melting loss, 15.5 per cent.

Fluidity strips ran up poorly. Iron dull. Heat very unsatisfactory. Bottom dropped at tenth ladle.

Foundry test No. 15, on coke made from Kentucky No. 4 coal (washed), November 29, 1904.

[Coke from Wheateroft Coal and Mining Company, Wheateroft, Ky.]

ANALYSIS OF COKE.

	Per cent.
Sulphur.....	2.37
Sulphur in ash.....	.14
Volatile carbon.....	.63
Fixed carbon.....	86.50
Ash.....	12.35
Phosphorus.....	.015
Moisture.....	.52

Specific gravity, 1.84.

Appearance, 6 (Connellsville, 10).

CHARGE.

[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke.....	220	54	52	52	52	430
Pig iron.....	660	398	398	398	396	2,250
Scrap.....	220	194	192	192	192	750

RECORD OF MELT.

Blast pressure averaged 7½ ounces.

Blast on, 2.58 p. m.

Iron running, 3.03 p. m.

Iron in 5 minutes.

	Pounds.
Ladle No. 1, 3.08 p. m.....	110
Ladle No. 2, 3.11 p. m.....	120
Ladle No. 3, 3.14 p. m.....	150
Ladle No. 4, 3.17 p. m.....	250
Ladle No. 5, 3.19 p. m.....	200
Ladle No. 6, 3.21 p. m.....	275
Ladle No. 7, 3.23 p. m.....	177
Ladle No. 8, 3.24 p. m.....	200

	Pounds.
Ladle No. 9, 3.26 p. m.....	175
Ladle No. 10, 3.27 p. m.....	175
Ladle No. 11, 3.28 p. m.....	130
Ladle No. 12, 3.29 p. m.....	200
Ladle No. 13, 3.31 p. m.....	135
Total iron poured.....	2,297
Rate (pounds per hour).....	6,000
Iron recovered.....	303
Coke recovered.....	10

Melting loss, 13.3 per cent.

Fluidity strips ran up fairly well. Iron very good and hot. If sulphur can be kept lower this should be a good foundry coke.

Foundry test No. 14, on coke made from West Virginia No. 1 coal (unwashed), November 29, 1904.

[Coke from Virginia and Pittsburg Coal and Coke Company, Kingmont, W. Va.]

	Per cent.
Sulphur.....	0.71
Volatile carbon.....	1.95
Fixed carbon.....	87.47
Ash.....	10.18
Phosphorus.....	.029
Moisture.....	.40

Specific gravity, 1.84.

Appearance, 6 (Connellsville, 10).

CHARGE.
[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke.....	180	64	62	62	62	430
Pig iron.....	540	432	426	426	426	2,250
Scrap.....	180	144	142	142	142	750

RECORD OF MELT.

Blast pressure averaged 7½ ounces.

Blast on, 10.20 a. m.

Iron running, 10.27 a. m.

Iron in 7 minutes.

	Pounds.
Ladle No. 1, 10.30 a. m.....	95
Ladle No. 2, 10.33 a. m.....	150
Ladle No. 3, 10.38 a. m.....	120
Ladle No. 4, 10.42 a. m.....	260
Ladle No. 5, 10.44 a. m.....	195
Ladle No. 6, 10.46 a. m.....	225

FOUNDRY TESTS OF COKE.

1375

	Pounds.
Ladle No. 7, 10.48 a. m.....	200
Ladle No. 8, 10.50 a. m.....	255
Ladle No. 9, 10.52 a. m.....	190
Ladle No. 10, 10.54 a. m.....	255
Ladle No. 11, 10.56 a. m.....	260
Ladle No. 12, 10.57 a. m.....	135
Ladle No. 13, 10.59 a. m.....	70
Ladle No. 14, 11.02 a. m.....	35
Total iron poured.....	2,445
Rate (pounds per hour).....	4,580
Iron recovered.....	205
Coke recovered.....	20

Melting loss, 11.7 per cent.

Fluidity strips ran up fairly well. Iron ran fairly well and hot. If composition can be kept right it should be a good foundry coke.

Foundry test No. 12, on coke made from West Virginia No. 2 coal (washed), November 28, 1904.

[Coke from Pitcairn Coal Company, Clarksburg, W. Va.]

	Per cent.
Sulphur.....	2.24
Sulphur in ash.....	.14
Volatile carbon.....	1.31
Fixed carbon.....	86.70
Ash.....	11.40
Phosphorus.....	.017
Moisture.....	.59

Specific gravity, 1.89.

Appearance, 7 (Connellsville, 10).

CHARGE.

[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke.....	210	55	55	55	55	430
Pig iron.....	630	405	405	405	405	2,250
Scrap.....	210	135	135	135	135	750

RECORD OF MELT.

Blast pressure averaged 7½ ounces.

Blast on, 10.53 a. m.

Iron running, 11.03 a. m.

Iron in 10 minutes.

	Pounds.
Ladle No. 1, 11.09 a. m.....	120
Ladle No. 2, 11.12 a. m.....	185

	Pounds.
Ladle No. 3, 11.13 a. m.....	165
Ladle No. 4, 11.15 a. m.....	85
Ladle No. 5, 11.17 a. m.....	180
Ladle No. 6, 11.19 a. m.....	120
Ladle No. 7, 11.21 a. m.....	160
Ladle No. 8, 11.23 a. m.....	170
Ladle No. 9, 11.25 a. m.....	170
Ladle No. 10, 11.26 a. m.....	220
Ladle No. 11, 11.28 a. m.....	175
Ladle No. 12, 11.31 a. m.....	230
Ladle No. 13, 11.33 a. m.....	170
Ladle No. 14, 11.34 a. m.....	125
Ladle No. 15, 11.35 a. m.....	65
Ladle No. 16, 11.38 a. m.....	25
Total iron poured.....	2,365
Rate (pounds per hour).....	5,250
Iron recovered.....	257
Coke recovered.....	15

Melting loss, 12.6 per cent.

Fluidity strips ran up well. Iron hot. Heat very good. Iron fluid. If sulphur can be lowered coke can be recommended for further trial.

Foundry test No. 8, on coke made from West Virginia No. 3 coal (washed), November 25, 1904.

[Coke from West Virginia Coal Company, Richard, W. Va.]

	Per cent.
Sulphur.....	1.19
Volatile carbon.....	.87
Fixed carbon.....	84.48
Ash.....	14.27
Phosphorus.....	.079
Moisture.....	.38

Specific gravity, 1.94.

Appearance, 7 (Connellsville, 10).

CHARGE.						
[In pounds.]						
	1.	2.	3.	4.	5.	Total.
Coke.....	220	54	52	52	52	430
Pig iron.....	660	398	398	398	396	2,250
Scrap.....	220	134	132	132	132	750

FOUNDRY TESTS OF COKE.

1377

RECORD OF MELT.

Blast pressure averaged 6½ ounces.

Blast on, 10.36 a. m.

Iron running, 10.46 a. m.

Iron in 10 minutes.

	Pounds.
Ladle No. 1, 10.51 a. m	100
Ladle No. 2, 10.53 a. m	150
Ladle No. 3, 10.55 a. m	130
Ladle No. 4, 10.57 a. m	145
Ladle No. 5, 11 a. m	260
Ladle No. 6, 11.01 a. m	155
Ladle No. 7, 11.03 a. m	220
Ladle No. 8, 11.04 a. m	160
Ladle No. 9, 11.06 a. m	240
Ladle No. 10, 11.08 a. m	145
Ladle No. 11, 11.11 a. m	100
Ladle No. 12, 11.13 a. m	95
Ladle No. 13, 11.15 a. m	50
Total iron poured	1,950
Rate (pounds per hour)	4,870
Iron recovered	578
Coke recovered	20

Melting loss, 15.7 per cent.

Fluidity strips ran up well. Iron hot. Heat ran very well. Coke can be recommended for further trial.

Foundry test No. 7, on coke made from West Virginia No. 4 coal (washed), November 24, 1904.

[Coke from West Virginia Coal Company, Bretz, W. Va.]

ANALYSIS OF COKE.

	Per cent.
Sulphur	0.69
Volatile carbon	1.15
Fixed carbon	85.42
Ash	13.23
Phosphorus	.019
Moisture	.20

Specific gravity, 1.94.

Appearance, 9 (Connellsville, 10).

CHARGE.

[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke	200	59	57	57	57	430
Pig iron	600	414	412	412	412	2,250
Scrap	200	138	138	138	136	750

RECORD OF MELT.

Blast pressure averaged 7½ ounces.
Blast on, 2.43 p. m.
Iron running, 2.52 p. m.
Iron in 9 minutes.

	Pounds.
Ladle No. 1, 3 p. m.	110
Ladle No. 2, 3.03 p. m.	215
Ladle No. 3, 3.05 p. m.	170
Ladle No. 4, 3.08 p. m.	270
Ladle No. 5, 3.09 p. m.	155
Ladle No. 6, 3.10 p. m.	245
Ladle No. 7, 3.12 p. m.	145
Ladle No. 8, 3.13 p. m.	245
Ladle No. 9, 3.14 p. m.	175
Ladle No. 10, 3.15 p. m.	265
Ladle No. 11, 3.16 p. m.	160
Ladle No. 12, 3.17 p. m.	90
Ladle No. 13, 3.18 p. m.	80
Total iron poured.	2,325
Rate (pounds per hour).....	7,750
Iron recovered.....	578
Coke recovered.....	25

Melting loss, 3.2 per cent.

Fluidity strips ran up well. Iron hot. Iron ran well from beginning to end. Coke can be recommended for further trial.

Foundry test No. 5, on coke made from West Virginia No. 4 coal (unwashed), November 23, 1904.

[Coke from West Virginia Coal Company, Bretz, W. Va.]

ANALYSIS OF COKE.

	Per cent.
Sulphur.....	0.82
Volatile carbon.....	1.43
Fixed carbon.....	86.10
Ash.....	11.85
Phosphorus.....	.031
Moisture.....	.62

Specific gravity, 1.84.

Appearance, 7 (Connellsville, 10).

CHARGE.

[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke.....	220	54	52	52	52	430
Pig iron.....	660	398	398	398	396	2,250
Scrap.....	220	134	132	132	132	750

FOUNDRY TESTS OF COKE.

1379

RECORD OF MELT.

Blast pressure averaged 7½ ounces.
Blast on, 3.16 p. m.
Iron running, 3.24 p. m.
Iron in 8 minutes.

	Pounds.
Ladle No. 1, 3.37 p. m.....	160
Ladle No. 2, 3.39 p. m.....	145
Ladle No. 3, 3.40 p. m.....	145
Ladle No. 4, 3.42 p. m.....	130
Ladle No. 5, 3.44 p. m.....	145
Ladle No. 6, 3.45 p. m.....	120
Ladle No. 7, 3.46 p. m.....	130
Ladle No. 8, 3.47 p. m.....	75
Ladle No. 9, 3.49 p. m.....	125
Ladle No. 10, 3.52 p. m.....	55
Ladle No. 11, 3.55 p. m.....	50
Total iron poured.....	1,280
Rate (pounds per hour).....	4,270
Iron recovered.....	947
Coke recovered.....	40

Melting loss, 25.7 per cent.

Fluidity strips did not run up well. Iron dull. Very bad heat. Froze up at eleventh ladle and bottom had to be dropped. Tuyères bunged up soon after iron began to run.

Foundry test No. 10, on coke made from West Virginia No. 5 coal (unwashed), November 23, 1904.

[Coke from Davis Colliery Company, Coalton, W. Va.]

ANALYSIS OF COKE.

	Per cent.
Sulphur.....	0.79
Sulphur in ash.....	.053
Volatile carbon.....	1.14
Fixed carbon.....	78.81
Ash.....	19.54
Phosphorus.....	.067
Moisture.....	.51

Specific gravity, 1.90.

Appearance, 7 (Connellsville, 10).

CHARGE.

[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke.....	220	54	52	52	52	430
Pig iron.....	660	398	398	398	396	2,250
Scrap.....	220	134	132	132	132	750

OPERATIONS OF THE COAL-TESTING PLANT.

RECORD OF MELT.

Blast pressure averaged 7½ ounces.
Blast on, 10.46 a. m.
Iron running, 11.56 a. m.
Iron in 10 minutes.

	Pounds.
Ladle No. 1, 11 a. m.....	50
Ladle No. 2, 11.04 a. m.....	135
Ladle No. 3, 11.07 a. m.....	130
Ladle No. 4, 11.10 a. m.....	185
Ladle No. 5, 11.12 a. m.....	255
Ladle No. 6, 11.14 a. m.....	200
Ladle No. 7, 11.15 a. m.....	230
Ladle No. 8, 11.16 a. m.....	185
Ladle No. 9, 11.17 a. m.....	190
Ladle No. 10, 11.19 a. m.....	180
Ladle No. 11, 11.22 a. m.....	125
Ladle No. 12, 11.24 a. m.....	150
Ladle No. 13, 11.25 a. m.....	140
Ladle No. 14, 11.26 a. m.....	165
Ladle No. 15, 11.27 a. m.....	95
Ladle No. 16, 11.28 a. m.....	65
Ladle No. 17, 11.30 a. m.....	55
Total iron poured.....	2,535
Rate (pounds per hour).....	5,070
Iron recovered.....	233
Coke recovered.....	12

Melting loss, 7.7 per cent.
Fluidity strips ran up well. Iron hot. Heat very good. Coke can be recommended for further trial.

Foundry test No. 9, on coke made from West Virginia No. 5 coal (washed), November 25, 1904.

[Coke from Davis Colliery Company, Coalton, W. Va.]

ANALYSIS OF COKE.

	Per cent.
Sulphur.....	0.83
Sulphur in ash.....	.08
Volatile carbon.....	.43
Fixed carbon.....	84.34
Ash.....	14.81
Phosphorus.....	.086
Moisture.....	.42

Specific gravity, 1.89.
Appearance, 9 (Connellsville, 10).

FOUNDRY TESTS OF COKE.

1381

CHARGE.

[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke.....	230	50	50	50	50	430
Pig iron.....	690	390	390	390	390	2,250
Scrap.....	230	130	130	130	130	750

RECORD OF MELT.

Blast pressure averaged 8 ounces.

Blast on, 2.52 p. m.

Iron running, 3.07 p. m.

Iron in 15 minutes.

	Pounds
Ladle No. 1, 3.15 p. m.....	45
Ladle No. 2, 3.19 p. m.....	55
Ladle No. 3, 3.22 p. m.....	60
Ladle No. 4, 3.24 p. m.....	145
Ladle No. 5, 3.26 p. m.....	140
Ladle No. 6, 3.28 p. m.....	220
Ladle No. 7, 3.30 p. m.....	120
Ladle No. 8, 3.32 p. m.....	100
Ladle No. 9, 3.33 p. m.....	30
Ladle No. 10, 3.36 p. m.....	10
Total iron poured.....	925
Rate (pounds per hour).....	2,640
Iron recovered.....	1,734
Coke recovered.....	30

Melting loss, 10.3 per cent.

Fluidity strips ran up fair. Iron dull. Exceedingly heavy coke. Made poor fire. Iron long in melting and finally froze up cupola. Bottom had to be dropped.

Foundry test No. 6, on coke made from West Virginia No. 6 run-of-mine coal (unwashed), November 24, 1904.

[Coke from New River Smokeless Coal Company, Rush Run, W. Va.]

ANALYSIS OF COKE.

	Per cent.
Sulphur.....	0.70
Sulphur in ash.....	.049
Volatile carbon.....	2.20
Fixed carbon.....	90.84
Ash.....	5.21
Moisture.....	1.75

Specific gravity, 1.77.

Appearance, 8 (Connellsville, 10).

OPERATIONS OF THE COAL-TESTING PLANT.

CHARGE.						
[In pounds.]						
	1.	2.	3.	4.	5.	Total.
Coke.....	220	54	52	52	52	430
Pig iron.....	660	398	398	398	396	2,250
Scrap.....	220	134	132	132	132	750

RECORD OF MELT.

Blast pressure averaged 7½ ounces.	
Blast on, 11.19 a. m.	
Iron running, 11.25 a. m.	
Iron in 6 minutes.	
	Pounds.
Ladle No. 1, 11.37 a. m.	130
Ladle No. 2, 11.39 a. m.	175
Ladle No. 3, 11.40 a. m.	230
Ladle No. 4, 11.41 a. m.	160
Ladle No. 5, 11.42 a. m.	258
Ladle No. 6, 11.43 a. m.	250
Ladle No. 7, 11.44 a. m.	235
Ladle No. 8, 11.45 a. m.	155
Ladle No. 9, 11.47 a. m.	245
Ladle No. 10, 11.48 a. m.	115
Ladle No. 11, 11.50 a. m.	210
Ladle No. 12, 11.52 a. m.	115
Ladle No. 13, 11.53 a. m.	20
Total iron poured.....	2,298
Rate (pounds per hour).....	8,610
Iron recovered.....	320
Coke recovered.....	10

Melting loss, 12.7 per cent.
Fluidity strips ran up well. Iron hot. Iron ran well throughout heat. Coke can be recommended for further trial.

Foundry test No. 11, on coke made from West Virginia No. 6 pulverized coal (unwashed), November 26, 1904.

[Coke from New River Smokeless Coal Company, Rush Run, W. Va.]

ANALYSIS OF COKE.		Per cent.
Sulphur.....		0.70
Sulphur in ash.....		.076
Volatile carbon.....		1.85
Fixed carbon.....		89.60
Ash.....		7.55
Phosphorus.....		.006
Moisture.....		1.00

Specific gravity, 1.79.
Appearance, 9 (Connellsville, 10).

FOUNDRY TESTS OF COKE.

1383

CHARGE.
[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke.....	200	59	57	57	57	430
Pig iron.....	600	414	412	412	412	2,250
Scrap.....	200	138	138	138	136	750

RECORD OF MELT.

Blast pressure averaged 7½ ounces.
Blast on, 2.55 p. m.
Iron running, 3.01 p. m.
Iron in 6 minutes.

	Pounds.
Ladle No. 1, 3.08 p. m.....	100
Ladle No. 2, 3.10 p. m.....	170
Ladle No. 3, 3.11 p. m.....	180
Ladle No. 4, 3.13 p. m.....	250
Ladle No. 5, 3.14 p. m.....	150
Ladle No. 6, 3.16 p. m.....	235
Ladle No. 7, 3.18 p. m.....	250
Ladle No. 8, 3.19 p. m.....	230
Ladle No. 9, 3.21 p. m.....	175
Ladle No. 10, 3.22 p. m.....	235
Ladle No. 11, 3.24 p. m.....	160
Ladle No. 12, 3.26 p. m.....	195
Ladle No. 13, 3.27 p. m.....	65
Total iron poured.....	2,395
Rate (pounds per hour).....	7,560
Iron recovered.....	325
Coke recovered.....	18

Melting loss, 9.3 per cent.
Fluidity strips did not run up well. Iron dull. Iron not fluid though fairly hot.

Foundry test No. 2, on coke made from West Virginia No. 7 coal (unwashed), November 22, 1904.
[Coke from New River Smokeless Coal Company, Sun, W. Va.]

ANALYSIS OF COKE.

	Per cent.
Sulphur.....	1.03
Sulphur in ash.....	.035
Volatile carbon.....	1.23
Fixed carbon.....	90.40
Ash.....	7.70
Phosphorus.....	.006
Moisture.....	.67

Specific gravity, 1.80.
Appearance, 5 (Connellsville, 10).

OPERATIONS OF THE COAL-TESTING PLANT.

CHARGE.

[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke.....	210	55	55	55	55	430
Pig iron.....	630	405	405	405	405	2,250
Scrap.....	210	135	135	135	135	750

RECORD OF MELT.

Blast pressure averaged 7½ ounces.

Blast on, 12.43 p. m.

Iron running, 12.53 p. m.

Iron in 10 minutes.

	Pounds.
Ladle No. 1, 12.57 p. m.....	100
Ladle No. 2, 12.58 p. m.....	112
Ladle No. 3, 12.59 p. m.....	100
Ladle No. 4, 1 p. m.....	118
Ladle No. 5, 1.01 p. m.....	105
Ladle No. 6, 1.02 p. m.....	103
Ladle No. 7, 1.03 p. m.....	85
Ladle No. 8, 1.04 p. m.....	125
Ladle No. 9, 1.05 p. m.....	115
Ladle No. 10, 1.06 p. m.....	125
Ladle No. 11, 1.07 p. m.....	115
Ladle No. 12, 1.09 p. m.....	115
Ladle No. 13, 1.10 p. m.....	122
Ladle No. 14, 1.11 p. m.....	125
Ladle No. 15, 1.12 p. m.....	133
Ladle No. 16, 1.13 p. m.....	128
Ladle No. 17, 1.14 p. m.....	105
Ladle No. 18, 1.15 p. m.....	83
Ladle No. 19, 1.17 p. m.....	28
Ladle No. 20, 1.18 p. m.....	55
Ladle No. 21.....	10
Total iron poured.....	2,107
Rate (pounds per hour).....	6,020
Iron recovered.....	475
Coke recovered.....	72

Melting loss, 13.9 per cent.

Fluidity strips ran up very poorly. Iron dull. Results not satisfactory.

FOUNDRY TESTS OF COKE.

1385

Foundry test No. 4, on coke made from West Virginia No. 8 coal (unwashed), November 23, 1904.

[Coke from Gauley Mountain Coal Company, Ansted, W. Va.]

ANALYSIS OF COKE.

	Per cent.
Sulphur.....	0.70
Sulphur in ash.....	.04
Volatile carbon.....	.35
Fixed carbon.....	86.38
Ash.....	12.52
Phosphorus.....	.012
Moisture.....	.75

Specific gravity, 1.94.

Appearance, 8 (Connellsville, 10).

CHARGE.

[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke.....	220	54	52	52	52	430
Pig iron.....	660	398	398	398	396	2,250
Scrap.....	220	134	132	132	132	750

RECORD OF MELT.

Blast pressure averaged 7½ ounces.

Blast on, 11.18 a. m.

Iron running, 11.30 a. m.

Iron in 12 minutes.

	Pounds.
Ladle No. 1, 11.36 a. m.....	160
Ladle No. 2, 11.39 a. m.....	200
Ladle No. 3, 11.42 a. m.....	175
Ladle No. 4, 11.44 a. m.....	210
Ladle No. 5, 11.46 a. m.....	190
Ladle No. 6, 11.47 a. m.....	245
Ladle No. 7, 11.49 a. m.....	180
Ladle No. 8, 11.50 a. m.....	245
Ladle No. 9, 11.52 a. m.....	170
Ladle No. 10, 11.54 a. m.....	240
Ladle No. 11, 11.56 a. m.....	160
Ladle No. 12, 11.58 a. m.....	175
Total iron poured.....	2,350
Rate (pounds per hour).....	6,410
Iron recovered.....	445
Coke recovered.....	20

Melting loss, 6.8 per cent.

Fluidity strips ran up well. Iron hot. Standard brand of foundry coke used for comparison. Good hot iron except at very last. The fixed condition of test required a heavier coke bed than is good practice with this heavy coke. Hence it took 12 minutes to get iron, and left too little coke for the upper charges. Coke can be recommended for foundry use.

Foundry test No. 1, on coke made from West Virginia No. 10 coal (unwashed), November 21, 1904.

[Coke from Stuart M. Buck, Bramwell, W. Va.]

ANALYSIS OF COKE.

	Per cent.
Sulphur.....	0.58
Sulphur in ash.....	.072
Volatile carbon.....	.55
Fixed carbon.....	90.34
Ash.....	8.51
Phosphorus.....	.007
Moisture.....	.60
Specific gravity, 1.89.	
Appearance, 4 (Connellsville, 10).	

CHARGE.

[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke.....	180	63	63	63	61	430
Pig iron.....	530	430	430	430	430	2,250
Scrap.....	180	144	142	142	142	750

RECORD OF MELT.

Blast pressure averaged 7½ ounces.

Blast on, 1.55 p. m.

Iron running, 2.00 p. m.

Iron in 14 minutes.

	Pounds.
Ladle No. 1, 2.15 p. m.....	100
Ladle No. 2, 2.18 p. m.....	125
Ladle No. 3, 2.20 p. m.....	135
Ladle No. 4, 2.22 p. m.....	125
Ladle No. 5, 2.24 p. m.....	130
Ladle No. 6, 2.26 p. m.....	130
Ladle No. 7, 2.28 p. m.....	125
Ladle No. 8, 2.30 p. m.....	125
Ladle No. 9, 2.32 p. m.....	115
Ladle No. 10, 2.34 p. m.....	100
Ladle No. 11, 2.36 p. m.....	85
Ladle No. 12, 2.38 p. m.....	40
Total iron poured.....	1,335
Rate (pounds per hour).....	3,480
Iron recovered.....	240
Coke recovered.....	45
Melting loss, 52.5 per cent.	

Fluidity strips did not run up well. Iron ran very dull. Became very hot after tenth ladle, when iron began to burn up in cupola. Great quantities of slag formed, choking up tuyères. Heat stopped and bottom dropped.

FOUNDRIY TESTS OF COKE.

1387

Foundry test No. 3, on coke made from West Virginia No. 12 run-of-mine coal (washed), November 22, 1904.

[Coke from Big Sandy Coal and Coke Company, Big Sandy, W. Va.]

ANALYSIS OF COKE.

	Per cent.
Sulphur.....	1.05
Sulphur in ash.....	.14
Volatile carbon.....	.75
Fixed carbon.....	90.37
Ash.....	7.88
Phosphorus.....	.010
Moisture.....	1.00
Specific gravity, 1.88.	
Appearance, 5 (Connellsville, 10)	

CHARGE.

[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke.....	210	55	55	55	55	430
Pig iron.....	630	405	405	405	405	2,250
Scrap.....	210	135	135	135	135	750

RECORD OF MELT.

Blast pressure averaged 6½ ounces.
 Blast on, 3.22 p. m.
 Iron running, 3.30 p. m.
 Iron in 8 minutes.

	Pounds.
Ladle No. 1, 3.40 p. m.....	80
Ladle No. 2, 3.43 p. m.....	118
Ladle No. 3, 3.46 p. m.....	205
Ladle No. 4, 3.43 p. m.....	235
Ladle No. 5, 3.49 p. m.....	300
Ladle No. 6, 3.52 p. m.....	58
Ladle No. 7, 3.54 p. m.....	75
Ladle No. 8, 3.55 p. m.....	130
Ladle No. 9, 3.56 p. m.....	185
Ladle No. 10, 3.57 p. m.....	115
Ladle No. 11, 3.58 p. m.....	160
Ladle No. 12, 4.00 p. m.....	125
Ladle No. 13, 4.01 p. m.....	50
Total iron poured.....	1,836
Rate (pounds per hour).....	5,246
Iron recovered.....	983
Coke recovered.....	25

Melting loss, 6.0 per cent.

Fluidity strips ran up fairly well. Iron hot. Test satisfactory. Coke can be recommended for foundry work.

OPERATIONS OF THE COAL-TESTING PLANT.

Foundry test No. 13, on by-product coke, November 28, 1904.

[Coke from Semet-Solvay Company, Milwaukee, Wis.]

ANALYSIS OF COKE.

	Per cent.
Sulphur.....	0.79
Sulphur in ash.....	.12
Volatile carbon.....	.48
Fixed carbon.....	89.63
Ash.....	9.62
Phosphorus.....	.025
Moisture.....	.27
Specific gravity, 1.89.	
Appearance, 8 (Connellsville, 10).	

CHARGE.

[In pounds.]

	1.	2.	3.	4.	5.	Total.
Coke.....	220	54	52	52	52	430
Pig iron.....	660	398	398	398	396	2,250
Scrap.....	220	134	132	132	132	750

RECORD OF MELT.

Blast pressure averaged 7½ ounces.

Blast on, 3.20 p. m.

Iron running, 3.26 p. m.

Iron in 6 minutes.

	Pounds.
Ladle No. 1, 3.30 p. m.....	150
Ladle No. 2, 3.34 p. m.....	155
Ladle No. 3, 3.36 p. m.....	255
Ladle No. 4, 3.37 p. m.....	140
Ladle No. 5, 3.38 p. m.....	280
Ladle No. 6, 3.40 p. m.....	165
Ladle No. 7, 3.41 p. m.....	320
Ladle No. 8, 3.43 p. m.....	135
Ladle No. 9, 3.45 p. m.....	255
Ladle No. 10, 3.47 p. m.....	155
Ladle No. 11, 3.49 p. m.....	205
Ladle No. 12, 3.50 p. m.....	145
Ladle No. 13, 3.52 p. m.....	55
Total iron poured.....	2,415
Rate (pounds per hour).....	6,590
Iron recovered.....	276
Coke recovered.....	30

Melting loss, 10.3 per cent.

Fluidity strips ran up well. Heat very satisfactory. Iron hot and fluid all through heat. Coke can be recommended for foundry use, result being as good as from best Connellsville coke.

BRIQUETTING TESTS.

By JOSEPH HYDE PRATT.

INTRODUCTION.

The fuel supply of the world is becoming a more and more important question from year to year. This is especially true on the European continent. It does not yet attract so much attention in the United States, where the supplies of the various fuels seem almost unlimited. While for many years Europeans have been utilizing their waste coal by briquetting it and making a satisfactory fuel, little attention has been given to this industry in the United States. Briquetting has not attracted much attention in the United States because of the cheapness of good run-of-mine coal, the discovery of oil in sections where fuel had been expensive (as in California and Texas), and the high price and limited supply of material that would make suitable binders for briquettes. The recent advance in the price of coal in the United States, however, together with the recent miners' strikes in the coal regions of Pennsylvania and elsewhere (especially the anthracite-coal miners' strike of 1902), which resulted in a scarce and irregular supply of coal at a much increased price, have created a more general public interest in briquetting and have resulted in the establishment of a number of plants for the manufacture of coal briquettes. The results desired in coal briquetting are, first, to utilize the practically worthless culm or slack coal which is unavoidably obtained in mining; and second, to convert an inferior grade of coal, or one that crumbles easily, into a hard fuel containing more heat units. Again, many coals and lignites on being exposed to the air slack rapidly, while others contain so much sulphur or ash that they must be crushed and washed, and thus can not bear much expense for transportation, so that their markets are accordingly somewhat limited. Such coals, if they can be properly briquetted, will stand transportation and make a fuel superior to the original coal.

As is well known, in coal mining there is often produced a large proportion of fines, slack, or culm, amounting in some sections to over one-half of the coal

brought to the surface. In the United States much of this material has for years been thrown on the dump piles, and it is only recently that any serious attempt has been made to utilize any of it. This waste coal represents one of the products which it is desired to convert into a good marketable fuel.

The numerous bodies of lignite, or brown coal, found in several of the Western States are in themselves inferior fuels, but by briquetting they may be converted into hard fuels which, if not of equal value in heat units to the natural bituminous and semianthracite coals, are usable for domestic and steam-raising purposes. The principal difficulty in the utilization of the lignites is to obtain suitable binders at prices that will permit the manufactured briquette to compete with coal. This is due to the location of the lignite fields, which, in many instances, are situated at long distances from the sources of supply for binding materials.

Although the briquetting of coal is apparently a simple operation and has been commercially successful at many different localities in Europe, yet there are many mechanical, chemical, and financial difficulties to be overcome before it can be made a profitable industry in this country. In certain districts in the United States there are promising opportunities for the development of this industry, on account either of the inferior character of the coal at hand and the higher price of good coal, or of the favorable juxtaposition of coal and binding material, while in other districts, on account of the low price at which high-grade coal can be obtained, it is not feasible to attempt the manufacture of briquettes in competition with it. Thus in some districts the margin between the value of the culm or waste coal and the cost of good coal is so narrow, 75 cents to \$1, that it is impracticable to manufacture a briquette which can compete in the same market. On the other hand, however, where the margin is wider, as, for instance, when the cost of a good coal is \$1.15 to \$2 a ton or more, the briquetting of the coal culm or slack may be carried on profitably. In all cases consideration has to be given to the cost of the binder, for this will determine what binder can be used.

The work done at the coal-briquetting plant of the United States Geological Survey has shown that many problems connected with this industry, in its relation to the coals and lignites of the United States, are peculiar to certain districts, to certain coals, and to certain binders; that what is commercially possible in one district with a certain coal is impossible or impracticable in another district, either with a similar coal or with a decidedly different one; that one binder may be well adapted to one coal and not to another; that it is necessary to carefully investigate each district, each coal, and each binder, and to determine the temperature and pressure to which the mixtures must be subjected. Thus the lines of research are multiple.

The manufacture of briquettes at the experimental plant has in all cases been supplemented by work in the laboratory, and in nearly every case the results obtained in the laboratory have been closely checked by the actual run of briquettes on either the English or the American briquetting machines, which are described later.

ACKNOWLEDGMENTS.

In carrying out the investigations relating to the briquetting of coals the writer was very ably assisted by Prof. A. A. Steel, of the University of Arkansas, who superintended most of the experiments made on the regular briquetting machines and conducted almost all of the laboratory work. Material assistance was also rendered by Mr. Charles H. Smith, of St. Louis, in suggesting ways and means and in actual experimental work about the plant. Mr. William Chelly, of Swansea, Wales, who was in direct charge of the operation of the English machine, rendered considerable assistance, his suggestions regarding the use of various binders having been always valuable. Special acknowledgments are due to the Barrett Manufacturing Company, of St. Louis, and the Chatfield Manufacturing Company, of Carthage, Ohio, for supplies of various grades of pitch for binders; to Mr. C. C. Hawkins, chemist of the Chatfield Manufacturing Company, for suggestions and information regarding pitch, its analysis, etc.; to Dr. Hermann von Schrenk, of the Bureau of Forestry, for assistance in the rational analyses of pitch, and to Mr. Henry Woodhead, the representative of William Johnson & Sons, Leeds, England.

The analyses of pitches, asphalts, and coals given in this report, with the exception of the rational analyses of pitches, were all made at the chemical laboratory of the testing plant, under the direction of Prof. N. W. Lord, of Columbus, Ohio; the steam or boiler tests were made in the boiler room of the testing plant, under the direction of Prof. L. P. Breckenridge; and the coking tests were made in the beehive coke ovens of the testing plant, under the direction of Mr. Fred. W. Stammer.

BRIQUETTING PLANT.

MACHINES USED.

The briquetting plant consisted of two machines of distinctly different types. One of the machines was furnished by William Johnson & Sons, of Leeds, England, and is designated in this report the English machine. This machine is one of the standard type for briquetting with stiff pitch, and consists of a double-compression vertical table press, with closed molds and accessories. It was operated by a 50-horsepower inclosed motor, which was furnished by the Westinghouse Electric and Manufacturing Company, of Pittsburg, Pa.

The second briquetting machine was furnished by the National Compressed Fuel Company, of Chicago, Ill., and consists of a Chisholm, Boyd & White press, constructed on Belgium patterns, and accessories. This is ordinarily known as the eggette type of machine or press, but in this report is designated the American machine. This also was operated by a 50-horsepower motor, furnished by the Westinghouse Company.

Pl. XI, A, gives a view of the building in which the English machine was located. A building to the right of this contained the American machine. The apparatus to the left is the Bartlett direct-heat rotating drier, which was used in drying the coals and lignites.

ENGLISH MACHINE.

The English machine is illustrated in Pl. XI, B, which is a general view of the machine with some manufactured briquettes stacked to one side. In this plate A represents the pug mill, B the feed box, C the revolving table, D the molds, E the steel spring, and F the slide or table.

Coal is delivered to the English machine by an inclined conveyor, furnished by the Robins Conveying Belt Company, and is received upon a slightly raised platform, holding about 10 tons, from which it can be conveniently shoveled, through a hole in the floor, onto a coal-feeding worm. At the same time the pitch that is used as a binder, having been first reduced to lumps of suitable size, is fed into the pitch cracker, which reduces it to half-inch size and drops it upon a smaller worm, and this in turn delivers it onto the coal in the larger worm. The smaller worm is driven by sprockets from the larger one, and the percentage of pitch that is added to the coal can be varied by changing the wheels.

While this arrangement gives good results when the same coal and binder are used, it is not sufficiently flexible to be adapted to the differences in behavior of the various coals and binders that were used in the experimental work, and therefore, for most of the experiments, the crushed coal and cracked binder were weighed out on Fairbanks scales and mixed by hand. The mixed coal and binder were then fed through the hole in the floor onto the larger worm.

After a slight mixing in the larger worm the material enters an impact disintegrator, in which it is reduced to the desired degree of fineness. The speed of the disintegrator is varied according to the character of the coal. This variation is accomplished by running either one or both sides of the disintegrator and by tightening or slacking the belts. From the disintegrator the well-mixed, finely divided mass is elevated to a pug mill (A of Pl. XI, B), about 5 feet in vertical height, in which the pitch or other stiff binder is softened by contact with live steam. As there is no attachment on this machine for introducing or utilizing superheated



A. BUILDING CONTAINING ENGLISH BRIQUETTING PLANT.



B. ENGLISH BRIQUETTING MACHINE.

dipped by hand in the desired proportion and poured into the mixer. After a thorough mixing the mass is dropped into the feed slides of a tangential press. This press consists of two pairs of narrow-faced rolls (A of Pl. XII, *A* and *B*), in the cores of which are ovoid cups for receiving the mixture to be pressed. As these rolls revolve, the excess material is squeezed out, the pressure being dependent upon the viscosity of the mixture that is being compressed. The eggettes are delivered from under the press onto a short rubber belt (B of Pl. XII, *B*). They weigh on an average about 0.3 pound each.

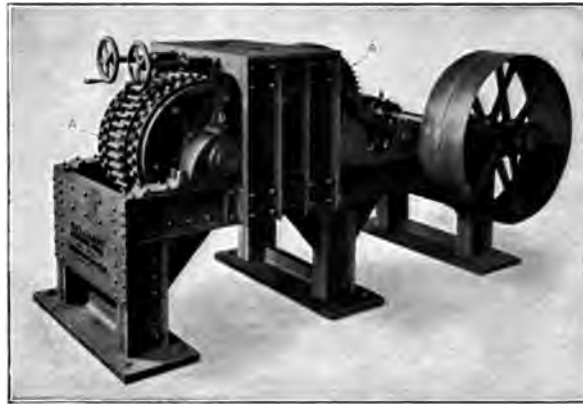
The capacity of the press is fully 5 tons of eggettes per hour, but the output of the mixing device was much too small for operating the press at its capacity. As arranged, this machine was adapted for the use of soft binders only, and it was necessary to grind the coal at the washery. For experimental work, however, it had one advantage over the larger English plant, inasmuch as it permitted the testing of mixtures in lots as small as 15 pounds, these small quantities being thrown directly into the feed hopper of the press. In making these small tests and those in which it was desired to use a stiff binder, a 35-gallon camp kettle was employed for heating the mixture. It was also possible to test on the American machine the mixtures used in the English machine, by crushing up some of the hot briquettes as soon as they were received from the molds and transferring them at once to the feed box of the American machine.

Pl. XII, *A*, *B*, are reproductions of photographs of the American briquetting machine, *B* showing in the foreground some of the eggettes that were made on this machine. In this plate *A* represents the narrow-faced rolls and *B* the rubber belt. In Pl. XII, *A*, there is represented a side view of an American eggette machine, similar to the one that was used, but mounted somewhat differently, which shows perhaps more clearly the arrangement of the tangential press, consisting of the two pairs of narrow-faced rolls.

In the experimental laboratory work use was made of a small hand press that was especially designed for this purpose. On this machine a pressure varying from 0 to 5,000 pounds per square inch can be obtained. The briquettes are cylindrical in shape, one-half inch in diameter, and can be made of any length from one-fourth inch to 1½ inches. The results obtained on this hand press were checked very closely by the briquettes made on the large machines, the formulas for the mixtures having been derived from experiments made with the small press.

BINDERS USED.

It was found that one binder would give good results with one coal, while it was impossible to use the same binder with other coals. Then again, on account of the location of the coal districts, it would be impossible to use commercially a



A. AMERICAN BRIQUETTING MACHINE.



B. AMERICAN BRIQUETTING MACHINE AT WORK.

binder which it was known would give good results, and another binder would have to be substituted for it. Thus, in the work done at the coal-testing plant an attempt has been made not only to obtain a binder with which the coal could be briquetted, but, as far as possible, to devise a binder that would make briquetting commercially possible. The greatest difficulty was experienced with the various grades of lignite coal, most deposits of which are too remote from supplies of available binders to make it possible to utilize certain materials for binding purposes that would otherwise give satisfactory results.

The materials that have been tried as binders in the laboratory experiments, and on the two briquetting machines, include the following: Pitch of various grades, creosote, asphalt (hard and soft, crude and refined), asphaltic pitch, petroleum (both of paraffin and asphalt bases), molasses, lime, and clay.

PITCH.

Pitch is the residue left from the distillation of tar which is obtained (1) from by-product coke ovens, (2) from illuminating-gas plants, (3) from producer-gas plants, (4) from Pintsch-gas plants, (5) from water-gas plants, and (6) from petroleum-gas plants. Pitches made from the first three varieties of tar were tested and gave equally good satisfaction when approximately of the same composition. Petroleum-gas tar gave the best results.

There is considerable variation in the tars obtained by the various processes mentioned above, the pitch obtained from different batches of the same tar often varying greatly, even when distilled to the same final temperature. In order to obtain a uniform grade of pitch it is necessary to keep the fire at approximately the same intensity, and it is usually considered advantageous to use the same still for the same tar. Tar obtained from by-product coke ovens differs in quality from tar made at illuminating-gas works, probably because the condensers of the former are kept at a temperature so high that the available benzole does not enter the tar, but is recovered separately. The by-product oven pitch usually contains much more fixed carbon than that obtained from gas-house tars.

One objection to the use of producer-gas tar is that it contains much more water than the other tars, and this water is more intimately mixed with the tar and harder to remove.

Pintsch-gas tar is obtained as a thin emulsion in water, from which it can be separated only by standing long in a tank at a temperature just below 212° F. The tar is composed largely of naphthalene and benzine. The price of coal-gas tar varies considerably, reaching at times 3 cents per gallon. The entire output of tar from many illuminating-gas and by-product coke plants is now purchased by

pitch manufacturers. Prices were obtained from the Laclede Gas Company, of St. Louis, Mo., which quoted 6 cents per gallon for illuminating-gas tar, guaranteed to contain less than 10 per cent moisture. An average sample of this tar contains 5.25 per cent water, gives 14,172 British thermal units, and has a specific gravity of 1.21. Water-gas tar is sold at 4 cents per gallon, averages 6.75 per cent of water, and gives 15,325 British thermal units. Its specific gravity is 1.12. At present there is no market for Pintsch-gas tar, which has always been sold cheaper than water-gas tar. When dried, this tar contains 4 per cent water, gives 12,304 British thermal units, and has a specific gravity of 1.18.

The pitches submitted to the plant for the experimental work varied considerably, and at the beginning it was difficult to obtain pitch of the grade desired. The first pitch received was from the St. Louis works of the Barrett Manufacturing Company. The pitch was too hard and would not soften at a temperature sufficiently low to be used satisfactorily in either the English or the American machine. It was subsequently shown that the pitch did not contain a sufficient quantity of the creosote oils to give it the required binding qualities. Throughout this report this pitch is designated as pitch A. The second lot of pitch was received from the Chatfield Manufacturing Company, of Carthage, Ohio, and was somewhat harder than pitch A, indicating that a still greater per cent of the creosote and lighter oils had been driven off. Although these pitches would make briquettes, it was necessary to use from 13 to 18 per cent of them, while of a pitch containing the proper amount of light oils only from 6 to 9 per cent would be required with the same coals. This pitch is designated throughout this report as pitch X.

In order to determine the quality of pitch that would be satisfactory, some of the best tar from the producer-gas plant was heated until all the water was expelled. The boiling was continued until the residue became brittle when dropped into water having a temperature of 55° F. After bucking down, this pitch stuck together on standing one week in the laboratory. It is known throughout this report as pitch Z. A long series of tests was then made with this pitch upon various coals, and it was found that 6 per cent of it made better briquettes than 13 per cent of pitch X. In order to demonstrate further that the right quality of pitch required a higher percentage of the creosote or adhesive oils than pitches A or X, experiments were made with hard pitch A and water-free producer-gas tar. These were melted together in various proportions until a product was obtained which became brittle when dropped into water at 55° F. A sufficient quantity of this product to briquette 2 tons of coal was made, and it was found to give the results desired. This pitch will soften when held in the mouth; when first bitten it cracks and crumbles like spruce gum, but almost immediately becomes plastic and can be chewed like ordinary gum. This simple test, in nearly all cases, will positively determine whether a pitch is of the proper

quality for briquetting. This pitch is designated throughout this report as pitch Y. Samples of it were sent to the Barrett Manufacturing Company and the Chatfield Manufacturing Company, and pitch of the right quality was obtained in quantity. The pitches received later from the Barrett Manufacturing Company are designated in this report as pitches B, C, and D. Those received from the Chatfield Manufacturing Company are known as pitches E, F, and G.

Another pitch that was furnished by the Barrett Manufacturing Company was obtained as a by-product from the manufacture of gas from heavy petroleum. When hot this pitch has a marked odor of kerosene, but it would not mix with Kansas crude oil. It is lustrous and works well on a cool day, but is a little too soft in ordinary weather for experimenting on the English machine. This pitch is designated as pitch H throughout this report.

Analyses have been made of pitches A, B, C, D, E, F, G, H, and X, by Mr. E. E. Somermeier, in charge of the chemical laboratory of the testing plant, with the following results:

Proximate analyses of pitches.

Pitch.	Laboratory No.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
A.....	1161	0.47	47.93	50.79	0.81	^a 0.62
B.....	1311	1.14	49.66	47.88	1.32	.70
C.....	1391	.88	62.75	35.84	.53	.57
D.....	1465	1.45	54.05	43.91	.59	^a .56
E.....	1464	1.02	54.11	44.04	.83	^a .66
F.....	1457	.57	52.98	45.31	1.14	^a .80
G.....	1453	.60	52.53	45.62	1.25	^a .70
H.....	1555	1.04	61.44	36.72	.80	.....
X.....	1125	.33	59.07	39.44	1.16	.88

^a Approximately determined.

Ultimate analyses of pitches.

Pitch.	Laboratory No.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Sulphur.	Calorific value.
A.....	1161	4.17	91.30	0.85	2.25	^a 0.62	.....
B.....	1311	3.97	90.89	1.05	2.07	.....	8,782
C.....	1391	4.72	91.16	1.16	1.85	.58	8,937
D.....	1465	4.28	91.57	1.10	1.90	.56	.....
E.....	1464	4.22	91.30	1.00	1.99	.66	.....
F.....	1457	4.16	91.50	1.00	1.40	.80	.....
G.....	1453	4.06	90.82	1.01	2.16	.70	.....
X.....	1125	4.56	90.34	.99	2.07	.88	8,820

^a Determined by Eschka method.

Although no definite conclusions can be drawn from the results of these analyses, yet they show that among pitches distilled from the same tar, under like conditions, those with the highest percentage of volatile matter will give the best results in briquetting. There may be, however, a wide variation in the percentage of the volatile matter between two pitches made from different tars and distilled under different conditions, and yet they may be of approximately the same quality for binding purposes. Thus pitches E, F, and G, furnished by the Chatfield Manufacturing Company, made from the same tar and distilled under approximately the same conditions, showed binding power that increased from G to E according to the increase in the percentage of volatile matter and the decrease in the percentage of fixed carbon. On the other hand, pitch B, which was made under entirely different conditions and from a different tar, is much lower in volatile matter and higher in fixed carbon than E, yet makes a better pitch for briquetting than either E, F, or G.

In order to obtain a more definite estimate of the influence of the composition of pitches on their binding qualities and their value in briquetting, a series of tests was made by distilling off their volatile contents. For this purpose a small copper still was constructed and distillations were made in the laboratory of Dr. Herman von Schrenk. In carrying out these experiments, 200 grams of the pitch were placed in the still and heated gradually until there was nothing left but a coke residue. In every instance all the volatile matter had been driven off at a temperature of 400° F. and the residue was hard coke. The results of these distillations are given in the table below:

Distillation of pitches.

Pitch.	Laboratory No.	Quantity of pitch used.	Temperature at which first drop came over.	Temperature at which the last of the oil was observed to come off.	Percentage of oil.	Final temperature to which still was raised.	Residue.
		Grams.	° F.	° F.		° F.	
A.....	1161	200	380	385	1.36	400	Hard coke.
B.....	1311	200	351	.....	7.38	400	Do.
D.....	1465	200	332	375	13.01	400	Do.
E.....	1464	200	350	370	1.91	400	Do.
G.....	1453	200	324	382	.96	400	Do.
X.....	1125	200	391	.....	.71	400	Do.

The total percentage of oils given off during the distillation of the pitches was determined by collecting these and weighing them. These results, while not absolutely correct, as some of the oils escaped during distillation, are approximately

correct, and are sufficiently accurate for comparative purposes, one with another. It will be seen from the above table that there is a decided increase in the percentage of oils in the pitches, from those that are of little or no value for briquetting to those that gave the best results. Pitch X, which was the hardest pitch tested and which gave the least satisfaction, contains but 0.71 per cent of volatile oil, while pitch D, which was the most satisfactory of those given above, contained 13.01 per cent of oils. Pitches A and E, made by different companies but very much alike and of about the same grade, were not good pitches for briquetting. They contained 1.36 and 1.91 per cent of oils, respectively. Pitch G, which was harder than either A or E, and little, if any, better than pitch X, contained only 0.96 per cent of oil. Pitch B, which was one of the better ones used, approaching D in quality, contained 7.38 per cent of volatile oils. The experiments have shown that from 7½ to 14 per cent of these oils is necessary in the pitches in order to give them the binding qualities desired in briquetting. Pitches with a higher percentage of these oils are too soft and can not be used to advantage. Again, the oils driven off from 315° F. and under are the creosote oils, for which there is developing a large demand. They command a higher price than the pitches, being valued at from 5½ to 6 cents per gallon, or about \$15 per ton. Creosote was mixed with some of the hard pitches for binding purposes and the product gave satisfactory results.

ROSIN.

The cheaper grades of rosin can be used for binding purposes to as good advantage as the refined material, and, as far as could be judged from the work done in the laboratory, the crude, black rosin will give as good satisfaction as the partially refined. Rosin may, in some cases, be used to advantage for hardening as well as for binding purposes. It has been used with lime and pitch, and good briquettes were made with this combination. It was found that a better quality of briquettes could be made with a smaller percentage of a mixture of rosin and pitch as a binder than with pitch alone. In burning there is little or no odor from the rosin, although there is some tendency to smoke. Lime was used with the rosin to prevent, if possible, the smoking of the rosin briquettes.

ASPHALT.

The asphalt used in the experimental work was a California refined asphaltum of grade B, which is designated throughout this report asphalt B1. Another asphalt product of a rubbery consistency which was used is known as "kopak" No. 30. It is manufactured by the Raven Mining Company of Texas. This is known as asphalt B2. An asphaltic pitch made by the Waters-Pierce Oil Company at one of its Texas plants was also used. It is known as asphalt B3. Crude asphalt

from Indian Territory is known as B4. The last asphalt is altogether too hard, approaching a coke and containing but a small percentage of volatile matter.

A soft asphalt was received from the Gulf Refining Company, of Port Arthur, Tex., and is designated throughout this report as asphalt B5. An analysis of this asphalt by Mr. E. E. Somermeier was as follows:

Analysis of soft asphalt from the Gulf Refining Company.

	Per cent.
Moisture.....	0.00
Volatile matter.....	80.75
Fixed carbon.....	19.25
Ash.....	.00
Total.....	100.00

Another soft asphalt was furnished by Mr. John McNeil, from Casper, Wyo., and is known throughout this report as asphalt B6. It is a soft, tough asphalt, which on cooling to about 40° F. became brittle. An analysis by Mr. E. E. Somermeier gave the following results:

Analysis of asphalt from Casper, Wyo.

	Per cent.
Moisture.....	0.48
Volatile matter.....	78.77
Fixed carbon.....	20.75
Ash.....	.00
Total.....	100.00

PETROLEUM.

Petroleum of both paraffin and asphaltum bases may sometimes be used to advantage in briquetting. On account of lack of time little experimental work was done with the petroleums. Those that were used were crude oil from Spindletop, Tex., produced by the Gulf Refining Company, and a petroleum also from the Beaumont district, produced by the Great Southern Refining Company. The latter had a gravity of 15° Baumé, with a flash test of 505 and fire test 570. These are designated P1 and P2, respectively, throughout this report.

The only other oil that was tested in briquetting was a Kansas crude oil, which is designated throughout this report as P3.

MOLASSES.

These experiments were made with molasses in order to determine the possibility of utilizing waste products from cane and beet sugar refineries in briquetting ~~these~~ ~~molasses~~ coals that occur in the vicinity of the refineries. Although no

positive results have been obtained with this binder, the work has shown the probability that such waste products can be utilized, in connection with certain other materials, to give a satisfactory binder.

LIME.

Lime has been used in combination both with rosin and with molasses and some encouraging results were obtained. With the former the lime was used principally to prevent smoking. One of the main objections to using more than a small amount of lime is the fact that it increases the percentage of ash in the fuel without raising its heating efficiency. On the other hand, however, it is one of the cheapest binders and may be obtained at places that are easily accessible to most of the coal districts.

CLAY.

A few experiments were made with clay in combination with other compounds in an attempt to obtain a suitable binder for lignitic coals, but without success.

LABORATORY EXPERIMENTS.

In testing the value of the various binders for the briquetting of coal, a series of experiments with each was made in the laboratory by briquetting the mixture on a hand press. The mixture of coal and binder was heated in a clay assay crucible over a Bunsen burner. In most cases they were heated only to about 212° F., but where the binder was softened with difficulty the temperature was increased. Until the regular hand press was completed, the experiments were made on a screw press with a steel mold about three-eighths inch in diameter. This could be used satisfactorily, but there was no way of determining the amount of pressure applied.

The various coals, after they had been heated with the different binders, were tested in the press with varying pressures on the same mixtures. Thus, for each mixture there would be a series of 6 briquettes made, representing, respectively, a light pressure, moderate pressure, a pressure of 2,500 pounds, 4,000 pounds, and the maximum pressure of about 5,000 pounds. The quantity of mixture fed into the mold was also varied, so that some of the briquettes made were only one-fourth of an inch in length, while others were an inch in length in the direction in which the pressure was applied. All the briquettes made with a particular mixture gave practically identical results with the same length of briquette and there was usually but slight variation with briquettes made under different pressures. Where there was a decided difference, due to either the length of the briquette or the pressure applied, this is indicated in the description of the briquette.

PITCHES.

General results.—Special experiments were made with the different pitches, A, B, etc., and where there was considerable variation in their composition more complete experiments were made. The results of experiments made with one of similar pitches, however, as B, C, and D, were regarded as significant of what could be done with the others.

All of the pitches mix with gas tars and creosote, making a softer mass which resembles the softer pitches. They also mix with rosin in any proportion, giving a mass having the expected intermediate properties. They will not, however, mix to any noticeable extent with any of the Kansas or Texas crude oils or the refined Texas petroleum (as P2), or with hard Indian Territory asphalt (B4), California asphalt (B1), Texas rubbery asphalt (B2), the asphaltic pitch (B3), or the soft asphalt (B5). Experiments showed that rosin and oil would mix in all proportions, and such mixed masses of rosin and oil were tried in combination with the pitches, but on adding the pitch to this combined oil and rosin it was found that the oil was liberated and the resultant mass was granular and greasy, without any strength whatever. Another experiment showed that crude oil would neutralize the effect of clay in a coal, and although it was hoped that a combination of oil and pitch might be used it was found that the crude-oil products would not mix with any of the tar pitches, and thus no positive results could be obtained by such combination.

The experiments made with pitch as a binder, when heated to 212° F., indicate that the results are better when there is a slight amount of steam present. When coal and pitch, mixed together with a small amount of water, were heated in a clay crucible until steam began to come off freely and were then pressed, much better results were obtained than if the two were heated dry to the same temperature, or if the wet mixture were heated until all the water had been evaporated.

Pitch A.—Experiments were made in the laboratory with pitch A in order to determine its binding qualities. Nine per cent of this pitch A was mixed with Arkansas No. 1 coal and squeezed to the limit of the screw press. The warm mixture yielded a highly-polished cylindrical briquette, which, after remaining in a beaker of boiling water for two hours, showed no noticeable softening. This same mixture was further heated until the pitch began to smoke and was then put through the screw press. The resulting briquette was smooth and clean.

Seven per cent of pitch A and Arkansas No. 4 coal, when heated in an assay crucible and run through the hand press, made a fair briquette which burned well. Six per cent of this same pitch and Arkansas No. 6 coal, heated in the same way and with the maximum pressure of the hand press, made a crumbly briquette.

Alabama No. 1 coal was also tested with pitch A, the coal having been previously crushed to pass a 60-mesh sieve. With 7 per cent pitch A, when

the mixture was heated so as nearly to burn the fingers, the resultant briquettes were just beginning to cohere. With 9 per cent, it made a well-pressed, coherent, but rough briquette. With 11½ per cent, the briquettes were little or no better, except that they were somewhat cleaner. With 20 per cent, when the mixture is only just warm, but with a maximum pressure, the resultant briquette was good. All these briquettes were, however, dirty.

The above experiments show that the best practical results with this hard pitch were obtained by using 9 per cent of it with an easily briquetting coal; with other coals the percentage should be much higher.

Pitch A was further tested with rosin, first with 2 per cent of pitch and 3 per cent of rosin. The resultant briquette was hard but not strong. With 4 per cent of rosin and 2 per cent of pitch A the briquettes were somewhat better and were cleaner and harder than the ones made with 7 per cent of pitch A alone, but no satisfactory results were obtained with pitch A and rosin. A more detailed description of these results is given under the head of "Rosin," page 1408.

Pitch B.—This pitch was tested with West Virginia coking coal. With 3 per cent of pitch B a fair briquette was obtained. With 4 per cent the resulting briquette was a little better, and with 5 per cent a good briquette was made which had the desired lustrous fracture. With Arkansas No. 4 coal 6 per cent of this pitch was needed to give the desired results, and, as this coal represents more nearly the character of the coals to be briquetted this was accepted as the percentage required of this and the similar pitches C and D to make a good briquette. A series of experiments was also made with this pitch and lime. Arkansas No. 4 coal was used with 5 per cent lime and 1 per cent pitch B and steam. A briquette was obtained that, even after standing one day in order to allow the binder to set, was very incoherent. With 4 per cent lime and 2 per cent pitch B the resultant briquette was somewhat better. Three per cent lime and 3 per cent pitch B gave still better results, especially with an increase of pressure. With 2 per cent lime and 4 per cent pitch B a good briquette was obtained, but not so good as those with 6 per cent of pitch B alone. The experiments indicated that there is no advantage in using lime with pitch in an attempt to reduce the percentage of pitch. If, however, some third substance which will react with the lime can be used it may be possible thus to produce a binder which will be cheaper than pitch alone and quite as satisfactory.

Pitches C and D.—These, which are similar to B, were used with the formulas derived for B and in nearly all cases the runs made on the English and American machines were satisfactory.

Pitch E.—This pitch, which melts at 180° F., is a trifle too hard for satisfactory briquetting on the English machine and is not equal to pitches B, C, or D. This pitch was tested alone on Illinois No. 4 coal, with 6, 7, 8, and 9 per cent pitch. With

6 per cent the briquette was noncoherent; with 7 per cent a fairly strong briquette was obtained; with 8 per cent a briquette was obtained that was nearly satisfactory; and with 9 per cent an excellent briquette was made. With Arkansas No. 5 coal, which makes an excellent briquette with 6 per cent of pitch B, it was necessary to use 8 per cent of pitch E to obtain a corresponding briquette. Pieces of this pitch, on being placed in the sun for ten hours, will stick together.

Another series of experiments with pitch E was made with Kentucky No. 2 coal. This coal was crushed so that half would pass through a 20-mesh sieve and half through a 10-mesh sieve. With 7 per cent of pitch E a briquette was obtained that was just coherent; with 8 per cent the briquette was nearly satisfactory; but with 9 per cent an excellent briquette was obtained similar to those made with the Illinois No. 4 coal.

Pitch G.—This pitch, which melts at 196° F., is too hard (as are A and X) to be used alone in briquetting. Seven per cent of pitch G and 1 per cent of creosote were used in briquetting Indian Territory No. 6 coal, the result being a rather crumbly briquette. One and a half per cent creosote and 6½ per cent pitch G with the same coal makes a briquette which is soft when first taken from the mold, but which after standing twenty-four hours is fairly strong and hard. With 1½ per cent creosote and 8 per cent pitch G a better briquette was obtained, which, however, was still soft and crumbly and not so good as those made of 1 per cent creosote and 7 per cent pitch. With 1½ per cent creosote and 8 per cent pitch G, a good briquette was obtained that disintegrated but little in the fire, and this formula was used in making a trial run of briquettes on the English machine.

This pitch was also tried with Indian Territory No. 6 coal by using 1 per cent of Kansas oil, 2 per cent rosin, and 4 per cent of the pitch. The briquette obtained, while coherent, breaks easily, having but little strength, and is greasy. Without the oil it is dry and crumbly.

Pitch X.—This pitch, which contained only 0.71 per cent of volatile matter, was tested with a number of the coals and it was found that from 13 to 20 per cent was required to make a briquette that was at all coherent. Experiments were made with this pitch with 70 per cent Pennsylvania No. 2 anthracite coal and 30 per cent West Virginia No. 1 bituminous coal. To these mixed coals was added 8 per cent of pitch X. The briquettes were incoherent and crumbly. With 10 per cent of pitch X they were somewhat better; with 11 per cent the briquette was coherent and hard; with 12 per cent still better, and with 13 per cent they were very satisfactory. Briquettes were also made by using 12 per cent pitch X with a mixture of coal containing 80 per cent of the anthracite and 20 per cent of the bituminous and with 60 per cent of the anthracite and 40 per cent of the bituminous. All of these made good briquettes that burned without any disintegration in a muffle. Pennsylvania

No. 2 anthracite coal was also tested alone with 12 per cent pitch and the resultant briquette was satisfactory. In all of the above cases the mixture was heated in an assay crucible until the pitch softened. No experiments on the English machine, however, could be made with these combinations.

Pitch Z.—The gas-producer pitch Z was tested with Arkansas No. 3 coal by using 6.7 per cent of the pitch. While hot these briquettes were soft, but upon standing one hour they became very hard and had a glossy or lustrous fracture. When tested in the muffle they burned without disintegration.

ASPHALTS.

Asphalts were used alone as a binder and also in combination with other compounds. A number of satisfactory results were obtained in the laboratory work, but only a few of the asphalts could be tried on either the English or American machine, neither of which was adapted to the use of such mixtures.

California asphalt, B1.—This asphalt is brittle at ordinary temperatures and can be readily disintegrated. At 212° F. it softened slightly, and it is soft and very sticky after melting. It mixes readily with the Spindletop, Tex., petroleum, P1, and the residual product of Beaumont petroleum, P2, in all proportions, and can therefore be thinned to any consistency. A series of experiments was first made with 4 per cent of this asphalt and Arkansas No. 5 coal, from which a fair briquette was obtained. With 5 per cent the briquette is satisfactory, and with 6 per cent it is only a little better. By using 6 per cent of the asphalt, moistening the mixture, and then heating until steam came off, a briquette was obtained that was intermediate in quality between those made with 4 and 5 per cent, which were mixed dry and raised to a higher temperature. This indicates that to obtain the best results with this asphalt it would be necessary either to heat the mixture with superheated steam or to add crude oil.

This California asphalt was further tested with the Indian Territory No. 6 coal. With 7 per cent a poor briquette was obtained; with 8 per cent the briquette was somewhat better, but incoherent and crumbly, and with 10 per cent an excellent briquette was obtained that was strong and sufficiently hard, but showed many clayey streaks. These Indian Territory briquettes burned fairly well in the muffle.

Asphalt product (kopak), B2.—This Texas asphaltic compound is of a rubbery consistency at ordinary temperatures, and at 212° F. softened slightly without becoming sticky. It melted at a rather high temperature and was still rubbery, but very adhesive. Alone it can not be disintegrated readily in warm weather, but in a low temperature it can, with some care, be crushed. It is not affected by the crude Texas oil, P1, or the residual petroleum from Texas, P2. With the warm asphaltic pitch it mixes readily and but little of this pitch is needed to make a soft, very sticky

mass. With ordinary coal-tar pitches this asphaltic compound will not mix at all. With rosin the rubbery asphalt mixes readily, and the resulting product can be cracked quite easily. It is very strongly tenacious and somewhat elastic. This asphalt has qualities that should make it a desirable binder and it may perhaps be advantageously used in briquetting lignites.

This rubbery asphalt was tested with a dry Texas lignite, 12 per cent of the asphalt being used as a binder and heated hot without steam. The resulting briquette was excellent in appearance, tough and strong, but does not burn well, although it had more cohesion than a lignite briquette made with pitch. By using 12 per cent and heating with steam in the usual manner a briquette was obtained that was fully as strong as the one heated to a higher temperature. When the mold was warm a black, glossy briquette was produced which, in appearance, was one of the best lignite briquettes made. With 10 per cent of asphalt there was apparently no difference in the appearance of the briquette. They disintegrated in the furnace, however, and for this reason this line of experimentation was not pursued further.

This rubbery asphalt was further tested by using 6 per cent of it in combination with 4 per cent of the asphaltic pitch, B3, and the dry Texas lignite. The resultant briquette was soft when taken from the mold. After standing one hour it presented a fair appearance, but had no coherence when burning, showing that no advantage is to be gained by adding the asphaltic pitch.

Asphaltic pitch, B3.—This asphaltic pitch, made by the Waters-Pierce Oil Company at one of its Texas plants, was found to have excellent binding qualities and to be of the right consistency to work easily. This pitch was tested first with Arkansas No. 5 coal, by using 6 per cent of pitch as a binder and heating to a moderate temperature in an assay crucible. The briquettes were somewhat porous and not strong. By using 8 per cent of the pitch and moderate pressure a good briquette which stood up well in the fire was obtained. With Arkansas No. 6 coal 6 per cent of this pitch made a tough and elastic, but rather soft briquette. This pitch was also tried with Arkansas No. 5 coal by heating with steam. First 5 per cent of pitch was used and then 6 per cent, both proportions giving elastic briquettes, similar to those made by heating the dry mixture, but not so strong. The pitch may be said to make a tough and elastic briquette, but apparently it does not give the degree of hardness that can be obtained by using pitches made from coal tar.

Another test was made with this asphaltic pitch in combination with lime. Briquettes were made with Arkansas No. 5 coal by using 2 per cent of the asphaltic pitch and 4 per cent of lime as binder. The briquette showed little or no coherence when taken from the mold and no change in physical character at the end of forty hours. Three per cent of pitch and 3 per cent of lime made

a briquette that was only slightly better. Four per cent of pitch and 4 per cent of lime made a fair briquette, which was improved a little by an increase of pressure. Four per cent of pitch and 3 per cent of lime gave practically the same result. As there was apparently no reaction between the pitch and lime no advantage was gained in using lime.

A series of experiments was made with this asphaltic pitch in combination with rosin. Five per cent of the pitch and 1 per cent of rosin, when heated dry, made an excellent briquette with Arkansas No. 2 coal, but it was somewhat soft upon being taken from the mold and did not become hard after being exposed for twenty-four hours. With 4 per cent pitch and 2 per cent rosin a briquette was obtained that was satisfactory in every way. Three per cent pitch and 3 per cent rosin gave apparently the same results as 4 per cent pitch and 2 per cent rosin. With 2 per cent pitch and 4 per cent rosin a good briquette was obtained, which, however, was slightly brittle. One per cent pitch and 5 per cent rosin made a hard and strong briquette, but it was more brittle than the preceding. The briquettes made from 4 per cent asphaltic pitch and 2 per cent rosin and from 3 per cent pitch and 3 per cent rosin were of equal value; but as the 3 to 3 briquette would probably be the cheaper, this ratio has been adopted. For further tests of this pitch see page 1414.

Indian Territory asphalt, B4.—This asphalt does not soften at all in boiling water, even when tested as powder. It melts to a stiff, sticky liquid rather suddenly just below its ignition point, which is at a high temperature. It is only slightly soluble in gasoline. At the boiling point there is apparently no reaction between this hard asphalt and crude Kansas petroleum, P3, or the Spindletop oil, P1, or the residual petroleum, P2. Neither is there any apparent reaction between this asphalt and melted rosin. With creosote it softened materially, and when used with this in the ratio of 5 per cent of each with 90 per cent of Arkansas coal a fair briquette was obtained. With Pintsch-gas tar an apparent reaction took place which caused the separation of some of the contained water. One of the first tests made with this asphalt was to determine whether Kansas oil would have any softening effect on the asphalt, but no matter what quantity of oil was used, when heated with steam, only a noncoherent greasy mass was formed. The asphalt was also tried alone with Arkansas coal by using 4 per cent of asphalt. The mixture was used dry and worked at a high temperature, but the resulting briquette was poorly coherent. With 6 per cent of asphalt the briquette was little or no better. It is evident that the asphalt alone has no binding properties, its deficiency in this respect being probably due to its low percentage of volatile matter.

Wyoming asphalt, B6.—This asphalt united readily with rosin, and in preparing a mixture for briquetting two parts of asphalt and one part of rosin

were melted together in a kettle and then cooled over night. On a cool day this mass was very brittle, but became sticky with a rise in temperature. In using the mixture, one to two parts of lime were added to prevent its becoming too soft while hot. The briquettes made with this mixture were all right in appearance, but crumbled easily in burning. A Wyoming lignite, undried, was tested with 8 per cent of this mixture (two parts Wyoming asphalt with one of rosin) and 1 per cent of slaked lime. This made a good briquette, which burned fairly well. With 7 per cent of the mixture and 1 per cent of lime the result was practically the same. With 6 per cent of the mixture and 1 per cent of lime the briquette was crumbly. Seven per cent of the mixture alone without lime appears a little tougher when taken from the mold, but did not burn so well. Seven per cent of the mixture and 2 per cent of slaked lime was similar in result to the 7 per cent of mixture and 1 per cent of lime.

In testing this asphalt alone it was necessary to heat the coal in an assay crucible, add the fragments of asphalt, knead them together, and heat frequently. Six per cent of this asphalt alone would make with Wyoming lignite a strong, tough briquette which was slightly earthy in appearance. When tested in the fire, however, the briquette fell to pieces at once.

ROSIN.

Rosin alone used as a binder made hard, brittle briquettes, but they were not satisfactory, principally on account of their brittleness, which would prevent their standing rough treatment in transportation. The results of the tests made with rosin and pitch have been recorded under "Pitch" (p. 1402). Rosin mixes with almost all the crude oils and their residual products that have been tested in the laboratory. It mixes readily with the rubbery asphalt, B2, forming a still more rubbery mass, but does not unite at all with the Indian Territory asphalt, B4. All of the oils and petroleums increased the toughness of the rosin, and the consistency of the resulting mixtures varied from that of wagon grease to that of sticky rosin. Five parts of rosin melted with one part of Kansas crude petroleum gave a tough mass that could just be cracked when cold, and this seemed to be the best ratio for these two materials. With lime and rosin alone it was found that 15 per cent of lime and 85 per cent of rosin were the proportions required for a complete reaction. Rosin with unslaked lime sets after melting. If slaked lime is used the reaction occurs at 212° F., and the color of the mixture is light gray. This cement will soften and become sticky only at the melting point of lead. On cooling it is brittle, but stronger than rosin. With slaked lime rosin reacts and gives a satisfactory mixture up to 3 parts of rosin and 1 part of slaked lime. A combination of rosin and the residual Beaumont petro-

leum, P2, was made considerably tougher by the addition of lime, and for this relatively more lime is needed than when used with rosin alone. The best combination obtained was 6 parts of rosin to 3 parts of slaked lime and 2 parts of the petroleum P2. With Kansas crude oil no positive results could be obtained. Six parts of rosin, 3 of lime, and 4 of the Kansas oil, P3, gave a greasy, granular mass without any apparent binding properties. With 3 parts of oil instead of 4 a sticky mass was obtained which, however, had no strength.

Rosin was tested with sulphuric acid, and it was found that dilute acid had no effect on the rosin. Concentrated acid reacts with its own weight of rosin, evolving SO_2 and forming a stiff bright-red paste. There was apparently considerable free acid remaining in the paste which did not react with more rosin. When this paste was added to water there was formed a pink, soapy precipitate. Lignite was tested with 10 and 13 per cent, respectively, of this mixture, and a fair briquette was made in each case. These softened slightly on standing and disintegrated in the fire. They were of about equal quality and equivalent to a briquette made with a 12 per cent rosin.

A series of experiments was made with rosin and Kansas crude oil, P3, on Indian Territory No. 6 coal. With 5 per cent rosin and 1 per cent P3 oil a briquette was obtained which was poor when first taken from the mold, but which hardened after some hours of exposure. Six per cent rosin and 1 per cent P3 oil yielded a briquette which was slightly plastic and very tough and strong in a warm room, but brittle and somewhat crumbly in the cold. It required several hours to harden. Six per cent rosin and $1\frac{1}{2}$ per cent P3 oil gave a briquette which could be bent in the fingers, but which was no stronger than one made with 5 per cent of rosin and 1 per cent of oil.

Rosin, slaked lime, and the petroleum residue, P2, were mixed together in the proportion of 3 parts rosin to $1\frac{1}{2}$ parts slaked lime and 1 part petroleum, P2. This made a tough mixture that could be pulverized. Seven to 9.6 per cent of this mixture and Indian Territory No. 6 coal heated with steam made a fair-looking briquette. It was not, however, tough enough nor did it burn satisfactorily.

Another combination was tried by using 3 parts rosin to $1\frac{1}{2}$ parts slaked lime to 2 parts of Kansas P3 oil. This made a granular, nonbinding mass. With 2 parts of rosin to 1 of slaked lime and 1 of the P3 oil, a sticky, oily mass was obtained, but it was not at all tough.

Another series of experiments was made with the rosin and petroleum residue, P2. These were first tried with equal parts of each, which made a very sticky, plastic mass. With 6 parts of rosin and 4 parts of the petroleum P2 a mass was obtained that became hard when plunged into cold water. With 4 parts rosin and 1 part of the petroleum P2 a mass was obtained which was slightly brittle at

ordinary temperatures, but which melted completely at a temperature below 212° F. These proportions were therefore decided as the best and the mixture was tried with the Arkansas No. 5 coal by using 4 per cent of rosin and 1 per cent of the petroleum P2 as a binder. The resulting briquettes were the best that were made in the laboratory and were hard enough to dent wood. When thrown violently against a cement floor, they broke, with fracture across the grain and without any dirt. This briquette also burned exceptionally well. The Indian Territory No. 6 coal was tried with a mixture of 3 per cent rosin and 2 per cent petroleum, P2, but the briquette was oily, soft, and plastic. With a mixture containing 5 per cent of the rosin and 2 per cent of the petroleum P2 an excellent briquette was obtained. With 4½ per cent rosin and 1½ per cent of the petroleum P2 a briquette was obtained that was practically as good and represented the best proportion to be used with the coals of the type of Indian Territory No. 6. This briquette was nearly as good as those made with 10 per cent of the California asphalt, B1.

Other tests for rosin are given under the laboratory experiments made with the Texas lignite (pp. 1413-1416).

PETROLEUM.

All the crude oils and petroleums can be stiffened to some extent by mixing with rosin or hard pitch. None of the petroleum and oils that have been tested, however, could be used alone in briquetting any of the coals. Most of them were too fluid and had little or no binding qualities. The residual product obtained by refining some of the Beaumont oils, which had a gravity of 15° Baumé, was a stiff and sticky oil at ordinary temperatures. This oil, P2, was tried alone with Arkansas No. 5 coal, 6 per cent of the oil being used. The briquette obtained was greasy, flexible, and without sufficient strength or hardness.

The combinations made with petroleum have been previously described under pitch and rosin and are further described under the special laboratory work on the Texas lignite.

MOLASSES.

The molasses experimented with in the laboratory was that which can be bought in any market. It was always used in combination with lime. In using thick molasses it was found advantageous to dilute it with twice its weight of water, and the lime was slaked to a paste with twice its weight of water. When these two reagents were mixed together they had no apparent reaction until they were dried out. By using 1 part of water to 1 of molasses and 2 of lime there was no apparent excess of either, and the mixture set at once to a rather hard cement similar to plaster of Paris. A series of experiments was made with Arkansas No. 6 coal, by using slaked lime equivalent to 5 per cent of unslaked

lime, diluted molasses equivalent to 1 per cent of the undiluted, and 94 per cent of the coal. The briquettes were somewhat friable when taken from the mold, but became hard after standing six hours, and in twenty-four hours they were hard and strong. When immersed in water, they remained intact for about forty-eight hours, when they began to crumble. With a mixture equal to 3 per cent of unslaked lime and 3 per cent of undiluted molasses with 94 per cent of the coal, a briquette was obtained that was rather soft when first taken from the mold, but became hard in five hours. It burned with intumescence. With 1 per cent of lime and 5 per cent of molasses, a briquette was produced which hardened slowly and at the end of forty-eight hours was tough and elastic, but not hard. At the end of seven days this briquette had become extremely hard. In breaking it had a lustrous fracture and powdered only slightly. When tested in water, it took several days to soften and weaken it. This ratio of 5 molasses and 1 of lime gave the best results.

Another test was made by mixing dry 4 per cent of quicklime with the coal, and then adding 3 per cent of the molasses that had been previously diluted. The briquettes, as taken from the mold, were soft and crumbly, having little or no cohesion. A brown Texas lignite crushed, half to pass through a 10-mesh sieve and the other half to pass through a 20-mesh sieve, was dried and tested with the molasses and lime in the ratio of 5 to 1. The lime was first slaked to produce a dry, white powder, and the molasses was diluted with an equal weight of water. The very fine slaked lime equivalent to 1 per cent of unslaked lime and the lignite were mixed dry and then the diluted molasses, equal to 5 per cent of the pure molasses, was thoroughly mixed, a little at a time, with the mixed lime and lignite, enough extra hot water being added to thoroughly moisten the mass. The main difficulty was in making the lignite moist. With 5 per cent of molasses and 2 per cent of lime, the resultant briquette was just coherent, and many small intersecting perpendicular cracks developed on relieving the pressure. On standing forty-eight hours the cracks had not enlarged and the briquettes were hard, brittle, glossy, and brown. With 7 per cent of molasses and 2 per cent of lime, the briquettes were similar to the others when first taken from the mold, but became slightly harder in forty-eight hours and darker in color. With 7 per cent of molasses and 4 per cent of lime, fewer cracks developed on relieving the pressure, but the briquette was still soft. In forty-eight hours, however, it was noticeably stronger than either of the other two and of a blacker color. With 10 per cent of molasses and 3 per cent of lime, similar cracks developed on relieving the pressure, and on standing forty-eight hours the briquette was as hard as those with 7 and 4 per cent, respectively. With 14 per cent of molasses and 4 per cent of lime, a fair briquette was obtained when first taken from the mold. This was

somewhat crumbly, however, and at the end of forty-eight hours showed little change. The character of this briquette was not changed by using the extreme pressure obtainable on the screw machine. With 12 per cent of molasses and 4 per cent of lime, the briquette was better, but still not strong while fresh. In forty-eight hours it had hardened somewhat, but had developed many of the drying cracks. With 16 per cent molasses and 2 per cent lime, there was an excess of molasses, this being squeezed out in applying the pressure. This briquette was fairly good while fresh, but became too brittle on drying. It did not, moreover, stand up well in the fire. With the higher percentage of lime there was less tendency to crack, and while in the present series of experiments little lime was used in excess of the amount required for forming calcium saccharate, it may be that a further addition of lime would make a briquette that would behave better in the fire.

WAX TAILINGS.

A sample of wax tailings received from the Standard Oil Company was combined with Arkansas coal. With 98 per cent of coal and 2 per cent of wax no coherence was established under moderate pressure. With 4 per cent, either hot or cold, an elastic briquette was obtained which was fairly clean, but which yielded under slowly applied pressure. These briquettes were tested in a scorifier placed in a muffle, and seemed to burn perfectly. With additional pressure a briquette (containing 4 per cent wax) was obtained which, while it had no greater strength than the other, was smooth and clean. With 5 per cent of the wax and with light pressure, a briquette was obtained which was rather sticky and which showed an excess of wax by sticking to the plunger.

The wax was also tried with some of the harder pitches. With 1 per cent of wax and 3 per cent of pitch X a noncoherent briquette was obtained; 1 per cent of wax and 5 per cent of pitch X produced the same result, regardless of the pressure used; and with 2 per cent of wax and 4 per cent of pitch X a briquette was obtained similar to the one in which 13 per cent of pitch X alone was used. It was, however, not a satisfactory product.

ACID SLUDGE.

Some acid sludge was received from the Gulf Refining Company, of Port Arthur, Tex. It was mixed with water, producing a weak acid solution, which did not seriously attack iron. Part of this sludge was a thin, greasy mass, and the remainder was of a rubbery, granular consistency. These two parts did not mix when they were heated together to the melting point. The stiffer portion

of the sludge will mix with melted rosin, and this mixture resembles the rubbery petroleum, B2. On account of lack of time no further work was attempted with this acid sludge.

LIME.

No experiments were made with lime alone, as the percentage required for making a coherent briquette was so high as to preclude entirely its use as a binder. Lime was used principally with rosin and molasses in experiments that have already been described (see pp. 1408 and 1411).

CLAY.

Clay alone was tried up to 8 per cent, but in no case was a briquette obtained that would hold together on drying, although the clay used was a superior potter's clay. In making the laboratory briquettes the clay was used only in connection with lignite, in order to determine its effect on the strengthening of the briquettes. With 2 per cent of the clay little or no effect was noticed in the briquette when rosin and the petroleum P2 were used. With 4 per cent of clay the quantity of the other two required was reduced from 6 per cent to 5½ per cent each and made a briquette that held together somewhat better in the fire. On account, however, of the large increase in ash caused by the clay, no further tests were made with a higher percentage of clay.

COALS USED.

COLORADO NO. 1.

Colorado No. 1 coal, which is a black lignite, was tried without previous drying with pitch D. With 7 per cent of this pitch the briquette showed but little cohesion; with 9 per cent a fair briquette was obtained; while with 10 per cent a good one was made, which stood up fairly well in the fire. With 11 per cent the briquette was better than with 10, but it was decided to use 10 per cent in making a run on the English machine. A statement of the results of this run is given on page 1436.

TEXAS NO. 1 BROWN LIGNITE.

On account of the large areas of this lignite in Texas and the importance of utilizing it as a fuel, many experiments were made in the laboratory in the effort to devise, if possible, a practical binder that could be used for briquetting it. It was first tried with pitch alone and then with various combinations, the results of which, although mostly negative, are given below.

This lignite was first tried with pitch B, without previous drying but after crushing, so that one-third of that used was 40 mesh, another third 20 mesh, and the last third 10 mesh. With 6 per cent of pitch B heated in an assay crucible,

without the addition of any water to make steam, a noncoherent briquette was obtained. With 6 per cent of the pitch and steam a smoother and slightly better briquette was obtained. A briquette composed of this mixture, made with the maximum pressure while the material was hot, was smooth and firm, but began to disintegrate on standing twenty-four hours. A briquette made with lignite and steam alone and submitted to the maximum pressure was similar to that made with the 6 per cent pitch, but on standing one day it became very dry and crumbly. The lignite was then thoroughly dried, when it disintegrated to a powder, and it is evident that it must be at least partially freed from water before it can be briquetted with pitch.

Some of this dry Texas lignite was briquetted with 6 per cent of pitch B, without steam. The resultant briquette was noncoherent. With steam, however, it made a slightly better briquette. With 10 per cent of pitch B and steam a briquette was obtained which was fair when taken from the mold, but which, when tested in the fire, fell to pieces. With 12 per cent of pitch B a briquette was obtained that was also fair when fresh from the mold, but this also disintegrated immediately when placed in the fire. Kansas crude petroleum, P3, was added to the lignite and pitch mixture without beneficial results.

The next experiments were with the asphaltic pitch, B3, and rosin. With 3 per cent of this asphaltic pitch, 3 per cent of rosin, and 94 per cent of dry lignite, molded under very high pressure, a briquette which was only just coherent was obtained. With 4 per cent of this pitch and 4 per cent of rosin a fair briquette was obtained. Five per cent of the pitch and 5 per cent of rosin gave a fairly strong briquette, which crumbled slightly. With 6 per cent of each a briquette was obtained that was satisfactory physically, but crumbled in the fire. Ten per cent of pitch and 2 per cent of rosin, or 2 per cent of pitch and 10 per cent of rosin, made fair briquettes, but not equal to the 6 to 6. All of the briquettes made with the asphaltic pitch and rosin crumbled in the fire.

Another series of experiments was made on this lignite with rosin and lime. With 6 per cent of rosin, 2 per cent of quicklime, and 92 per cent of the dry Texas lignite, heated with steam, a briquette was obtained that had little or no coherence. With a mixture of 8 per cent of rosin and 90 per cent of lignite, to which was added 4 per cent of lime that had been boiled in water, a fair briquette was obtained. If this mixture is quite dry and is squeezed immediately on mixing, it will stand up in the fire better than a briquette made with rosin alone, but it is too soft to handle.

Another sample of the lignite was crushed to 10 and 20 mesh and heated until it was charred black. Twelve per cent rosin and 2 per cent lime, which had been previously mixed together in boiling water, when combined with the lignite made a briquette which was excellent physically, but which disintegrated in the fire.

Briquettes made of the lignite, previously mixed dry with 12 per cent of rosin and 2 per cent of quicklime and heated with steam, cracked through the center when the pressure was relieved, and fragments tested in the fire disintegrated completely. The charred lignite was then ground to 60 mesh and tested with 10 per cent of rosin and 2 per cent of lime, but there was no coherence at all in the briquette. With 12 per cent of rosin and 2 per cent of lime a poor briquette was obtained from this finely powdered material—one much inferior to that made by using the coarser charred lignite and the same ratio of rosin and lime. It also disintegrated completely in the fire. Another portion of the lignite, in quarter-inch fragments, was thoroughly charred and then crushed, one-half to 20 mesh and one-half to 10 mesh. With 12 per cent of rosin and 2 per cent of lime the resultant briquette was poorer than any of the previous ones.

It was thought that perhaps by mixing a bituminous coal with the lignite the binder would be more effective in holding the particles of lignite together. For this purpose a mixture was made that contained 10 per cent of Pocahontas coking coal, 8 per cent of rosin, 2 per cent of lime, and 80 per cent of the Texas lignite. A briquette was obtained which was physically successful, but it did not stand up in the fire any better than the others.

The Texas lignite with 8 per cent of lime alone and steam made a briquette that was good physically when first taken from the mold, but on drying it began to crumble, indicating that lime, except when used in very large quantity, would not successfully briquette this lignite.

Another series of experiments was made with the rubbery asphalt B2. With 12 per cent of asphalt B2, an excellent briquette was obtained by heating with the lignite and without steam. It was smooth and hard, but in the fire acted like the lime-rosin briquettes and crumbled. With 12 per cent of this asphalt heated with steam, the briquette was also physically good, and when the mold of the press was warm the resultant briquette was black and glossy. With 10 per cent of this asphalt and steam, the briquette was just as good. This briquette, however, did not stand up well in the fire. With 6 per cent of this asphalt and 4 per cent of the asphaltic pitch B3 and steam, the resultant briquette was almost noncoherent while warm, but became stronger on standing one hour. It was a fair briquette, but disintegrated in the fire.

The lignite was also tested with rosin and the petroleum P2. With 9 per cent of the rosin and 3 per cent of petroleum P2, the briquettes expanded immediately upon relieving the pressure, and large cracks developed. These cracks, however, closed up as the briquette cooled and the result was a briquette of fair hardness and strength, which, however, disintegrated in the fire. With 7 per cent of rosin and 5 per cent of petroleum P2, the resultant briquette was too soft, showing

the need of more rosin in the mixture. Some cracks developed, as in the previous ones, and in burning the briquette disintegrated completely. With 9 per cent of rosin, 3 per cent of petroleum P2, and 3 per cent of slaked lime, a good briquette was obtained that did not expand and crack upon relieving the pressure. It burned in the fire with some cohesion, but was no better than the rosin and lime alone, and there was apparently no advantage in adding the petroleum P2.

WEST VIRGINIA NO. 3.

This coal, which is a good coking coal, was tried in the laboratory to determine what could be done toward briquetting it without any binder whatever. Heated to 212° F. and then subjected to the maximum pressure on the hand press, a fair briquette was obtained without any binder. It was not strong, however, and caked in burning. When the coal was heated until it began to smoke, beautiful, polished briquettes were obtained, but these were but little stronger than the previous ones. When heated until caking began and then subjected to the maximum pressure, an excellent briquette was obtained.

OTHER COALS.

Many other coals were tested in the laboratory with the same end in view, and it was found that in nearly all cases a coking coal could be briquetted without the introduction of any binding material. In these experiments it was noted that the coal needed to be heated until it began to cake, and that it was necessary to feed the hot coal direct to the press, as even slight cooling seemed to diminish its briquetting properties. Another peculiarity indicated by a number of experiments was that after the coal has been heated until it began to cake and was then cooled and reheated, it had lost some of its briquetting properties.

COMPRESSION TESTS.

In order to obtain some standard of comparison between the briquettes, the crushing strength of many of them was determined in the compression testing machine exhibited by the Association of American Portland Cement Manufacturers, in its laboratory in the Cement Building at the World's Fair, St. Louis, Mo. The compressor was a 200,000-pound Olsen machine. When only a 1-ton lot was made the briquettes selected for these tests were the best ones obtained, as it was reasonable to suppose that in making a larger run the average briquette would be equal to the better ones made on the small lots. Of the 5 to 15 ton lots, the average briquettes were taken.

The briquettes were tested on the machine lengthwise, as that position gave a uniform area of 28.7 square inches, the cross-section area of the molds. The

thickness of the briquettes varied from 5.75 to 6 inches, depending upon the pressure. Any differences due to lack of parallelism between the ends were automatically corrected by the swiveling head of the machine. Pieces of millboard were placed between the briquettes and the steel. After a few preliminary tests, it was found that the slowest speed of compression was the most satisfactory. The tests made on this machine and their results were as follows:

Arkansas No. 4 coal with 6 per cent pitch B.

No.	Character of briquette made and speed of compression.	Load required to crush briquette having area of 28.7 square inches.
		<i>Pounds.</i>
1	Average good briquette with corners broken. Slow speed.....	18, 550
2	Excellent briquette. Highest speed.....	11, 050
3	Average briquette. Slow speed.....	14, 550
4	Rather porous, poorly pressed briquette.....	11, 250
	Average crushing strength used.....	17, 500
	Average crushing strength per square inch.....	610

Arkansas No. 4 coal with 3 per cent rosin and 3 per cent pitch A.

No.	Character of briquette made and speed of compression.	Load required to crush briquette having area of 28.7 square inches.
		<i>Pounds.</i>
1	Average slightly porous briquette. Medium speed.....	6, 850
2	Average briquette. Slow speed.....	9, 740
3	Good briquette, denser than 2 and apparently better. Slow speed.....	8, 100
4	Good briquette, but with corners broken.....	8, 520
	Average crushing strength used.....	8, 780
	Average crushing strength per square inch.....	306

OPERATIONS OF THE COAL-TESTING PLANT.

Illinois No. 4 coal with 6 per cent pitch D.

[Half disintegrator.]^a

No.	Character of briquette. ^b	Load required to crush bri- quette having area of 28.7 square inches.
		<i>Pounds.</i>
1	.....	6, 050
2	.....	3, 850
3	.....	4, 100
4	.....	6, 550
	Average crushing strength used.....	5, 100
	Average crushing strength per square inch.....	181

^aThis refers to the speed of the disintegrator. See p. 1392.
^bAll the briquettes of this lot were crumbly and most of them were badly cracked. Four of the better ones were selected.

Illinois No. 4 coal with 8 per cent pitch D.

[Half disintegrator.]

No.	Character of briquette.	Load required to crush bri- quette having area of 28.7 square inches.
		<i>Pounds.</i>
1	Average briquette, slightly porous.....	8, 480
2	A more compact briquette, but somewhat cracked.....	8, 680
3	A good briquette, better than the previous one.....	9, 950
4	A good briquette.....	10, 200
	Average crushing strength used.....	9, 327
	Average crushing strength per square inch.....	325

BRIQUETTING TESTS.

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Illinois No. 4 coal with 8 per cent pitch E.

[Full disintegrator.]

No.	Character of briquette.	Load required to crush briquette having area of 28.7 square inches.
		<i>Pounds.</i>
1	Briquette exhibiting cracks perpendicular to pressure.....	6,460
2	Good briquette with few cracks.....	6,050
3	do.....	6,340
4	Fair briquette with but few cracks.....	5,400
	Average crushing strength used.....	6,060
	Average crushing strength per square inch.....	209

Illinois No. 4 coal with 8 per cent pitch E.

[Half disintegrator.]

No.	Character of briquette.	Load required to crush briquette having area of 28.7 square inches.
		<i>Pounds.</i>
1	Good briquette, but somewhat porous.....	8,450
2	Apparently the same.....	6,870
3	do.....	6,960
4	Apparently more compact, but with cracks developed.....	6,780
	Average crushing strength used.....	7,265
	Average crushing strength per square inch.....	253

Illinois No. 4 coal with 9 per cent pitch E.

[Full disintegrator.]

No.	Character of briquette.	Load required to crush briquette having area of 28.7 square inches.
		<i>Pounds.</i>
1	Good briquette.....	10,420
2	Good briquette, but rather porous.....	8,370
3	Good briquette, showing some cracks.....	9,310
4	Good briquette, but corners broken off.....	8,400
	Average crushing strength used.....	9,125
	Average crushing strength per square inch.....	352

OPERATIONS OF THE COAL-TESTING PLANT.

Illinois No. 4 coal with 8 per cent pitch H.

[Half disintegrator.]

No.	Character of briquette.	Load required to crush bri- quette having area of 28.7 square inches.
		Pounds.
1	Good briquette.....	13, 900
2	Good briquette, with one crack developed.....	11, 950
3	Similar to 1.....	12, 050
4	do.....	11, 720
	Average crushing strength used.....	12, 810
	Average crushing strength per square inch.....	446

Indian Territory No. 6 coal with 7 per cent pitch D.

No.	Character of briquette. ^a	Load required to crush bri- quette having area of 28.7 square inches.
		Pounds.
1	.....	5, 150
2	.....	5, 400
3	.....	5, 200
4	.....	6, 650
	Average crushing strength used.....	5, 600
	Average crushing strength per square inch.....	195

^a The samples tested, although the best obtainable, were rather weak and crumbly, but on account of their porosity required more compression than usual before breaking.

Indian Territory No. 6 coal with 8 per cent pitch G and 1½ per cent of creosote.

No.	Character of briquette. ^a	Load required to crush bri- quette having area of 28.7 square inches.
		Pounds.
1	.....	6, 920
2	.....	5, 900
3	.....	6, 700
	Average crushing strength used.....	6, 500
	Average crushing strength per square inch.....	226

^a The briquettes that were tested were good average briquettes and the fragments were too hard and tough to be broken in the fingers.

BRIQUETTING TESTS.

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Indian Territory No. 6 coal with 6 per cent rosin and 1 per cent Kansas petroleum, P3.

No.	Character of briquette. ^a	Load required to crush briquette having area of 28.7 square inches. ^a
		<i>Pounds.</i>
1	Rather porous.....	4, 800
2	This one crushed very rapidly.....	4, 200
3	A smooth and perfectly shaped briquette, but one in which the rosin had not been perfectly melted.....	9, 240
4	Similar to 3.....	7, 400
	Average crushing strength used.....	6, 400
	Average crushing strength per square inch.....	223

^a For the compression tests the best-looking briquettes were selected.

Indian Territory No. 6 coal with 8 per cent asphalt B5.

No.	Character of briquette. ^a	Load required to crush briquette having area of 28.7 square inches. ^a
		<i>Pounds.</i>
1	Very porous.....	2, 400
2	Best briquette, heavy and firm.....	5, 100
3	Very porous.....	1, 800
4	A fair briquette, similar to 2.....	3, 550
	Average crushing strength used.....	3, 200
	Average crushing strength per square inch.....	111

^a All of these yielded considerably in the machine and would have given a higher crushing strength if they had been tested fast.

Kentucky No. 2 coal with 8 per cent pitch E.

[Half disintegrator.]

No.	Character of briquette.	Load required to crush briquette having area of 28.7 square inches.
		<i>Pounds.</i>
1	Good briquette.....	11, 650
2	do.....	11, 400
3	do.....	10, 460
4	Compact, but slightly cracked and crushed on only one side.....	11, 700
	Average crushing strength used.....	11, 300
	Average crushing strength per square inch.....	394

OPERATIONS OF THE COAL-TESTING PLANT.

New Mexico No. 1 coal with 8 per cent pitch D.

No.	Character of briquette. ^a	Load required to crush briquette having area of 28.7 square inches.
		Pounds.
1	Fair briquette.....	6, 820
2	do.....	6, 640
3	do.....	7, 900
	Average crushing strength used.....	7, 120
	Average crushing strength per square inch.....	248

^a All were the best selected briquettes.

New Mexico No. 1 coal with 10 per cent pitch D.

No.	Character of briquette. ^a	Load required to crush briquette having area of 28.7 square inches.
		Pounds.
1	Fair briquette.....	8, 000
2	do.....	4, 850
3	do.....	4, 850
	Average crushing strength used.....	5, 900
	Average crushing strength per square inch.....	206

^a These were also selected specimens from one ton lot.

New Mexico No. 1 coal with 8 per cent pitch H.

No.	Character of briquette. ^a	Load required to crush briquette having area of 28.7 square inches.
		Pounds.
1	Good briquette, but showing some cracks.....	12, 240
2	A perfect briquette.....	16, 650
3	do.....	10, 250
	Average crushing strength used.....	13, 050
	Average crushing strength per square inch.....	454

^a These were a much better briquette than those with the 10 per cent pitch D and represent the best lignite briquettes that have been made.

BRIQUETTING TESTS.

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Pennsylvania No. 3 coal with 7 per cent pitch B.

No.	Character of briquette. ^a	Load required to crush bri- quette having area of 28.7 square inches.
		<i>Pounds.</i>
1	Good briquette.....	16, 240
2	do.....	16, 550
3	Good, but faces not quite parallel.....	18, 450
4	Fair briquette, but somewhat open.....	9, 200
	Average crushing strength used, omitting No. 4.....	17, 100
	Average crushing strength per square inch.....	596

^a These briquettes had been exposed to the weather for over a month and were somewhat pitted by rain. They were, however, all good briquettes.

Pennsylvania No. 3 coal with 9 per cent West Virginia No. 3 coal and 7 per cent pitch B.

No.	Character of briquette. ^a	Load required to crush bri- quette having area of 28.7 square inches.
		<i>Pounds.</i>
1	A hard, well-formed briquette.....	5, 850
2	do.....	3, 700
3	do.....	5, 100
4	do.....	3, 100
	Average crushing strength used.....	4, 500
	Average crushing strength per square inch.....	156

^a These were all perfect briquettes and had also been exposed to the weather for over a month. The specimens used were all selected ones.

It is very evident from a comparison of these compression tests of the briquettes made with anthracite coal that the introduction of a soft coking coal with the anthracite reduces the crushing strength of the briquette, although it stands the weather somewhat better than the anthracite briquette with pitch alone.

Wyoming No. 1 dry coal with 8 per cent pitch H.

No.	Character of briquette. ^a	Load required to crush briquette having area of 28.7 square inches.
		<i>Pounds.</i>
1	A perfect briquette.....	6,950
2	A good briquette, but showing some cracks.....	7,200
3	A tough briquette showing a few cracks.....	11,700
4	A hard, tough briquette, with one imperfect face.....	10,500
Average crushing strength used.....		9,600
Average crushing strength per square inch.....		339

^a These briquettes were somewhat similar to the New Mexico No. 1, with 8 per cent of pitch H.

Briquettes made of coke breeze were also tested on the compression machine, with results shown below.

Coke breeze with 8 per cent of pitch D.

No.	Character of briquette and pressure used.	Load required to crush briquette having area of 28.7 square inches.
		<i>Pounds.</i>
1	Strong, hard briquette, maximum pressure.....	30,450
2	do.....	30,100
Average for compact briquettes.....		30,275
Average per square inch.....		1,055
3	Rather porous briquettes.....	22,100
4	do.....	22,800
Average for porous briquettes.....		22,450
Average per square inch.....		782

The coke-breeze briquettes were far stronger than any other made, as is indicated by the results of the compression tests.

While the results shown in the preceding tables are to some extent comparable one with another, they do not give the desired information regarding the actual strength or endurance of the briquettes, for in some instances the crushing strength is rather high, while the briquettes themselves could not have been handled to any great extent without breaking. The most satisfactory test for determining the strength of the briquettes would be afforded by a rattler or tumbler, such as is used for cleaning iron castings. This would give results that could be compared and would determine the relative strength of the briquettes and the amount of handling they could stand in transportation.

SPECIFIC-GRAVITY DETERMINATIONS.

In determining the specific gravity of the briquettes, fragments of those broken in the compression testing machine were used. Two or more determinations were made upon briquettes of the same character, each being made upon pieces of about 65 grams in weight, taken, as far as possible, from the different briquettes. The following are the results of the specific-gravity determinations:

Coal.	Binder.	Specific gravities determined.			Specific gravity used.
Arkansas No. 6.....	6 per cent pitch B.....	1.16,	1.24,	1.16	1.17
Do.....	3 per cent pitch A and 3 per cent rosin ..	1.12,	1.15,	1.13	1.13
Illinois No. 4.....	6 per cent pitch D (half disintegrator).....	1.16,	1.25,	1.15	1.16
Do.....	8 per cent pitch D (half disintegrator).....	1.11,	1.14,	1.10	1.11
Do.....	8 per cent pitch E (half disintegrator).....		1.13,	1.13	1.13
Do.....	8 per cent pitch E (full disintegrator).....	1.03,	1.06,	1.025	1.03
Do.....	9 per cent pitch E (full disintegrator).....		1.08,	1.075	1.08
Do.....	8 per cent pitch H (half disintegrator) ..	1.08,	1.15,	1.11	1.11
Indian Territory No. 6.....	7 per cent pitch D.....		1.19,	1.22	1.205
Do.....	8 per cent pitch A (1½ per cent creosote).....		1.21,	1.22	1.215
Do.....	8 per cent asphalt B5.....	1.19,	1.21,	1.25	1.22
Do.....	6 per cent rosin (1 per cent petroleum P3).....	1.25,	1.20,	1.27	1.25
Kentucky No. 3.....	8 per cent pitch E.....	1.12,	1.15,	1.13	1.13
New Mexico No. 1.....	8 per cent pitch D.....		1.13,	1.29	1.13
Do.....	10 per cent pitch D.....		1.016,	1.025	1.02
Do.....	8 per cent pitch H.....		1.07,	1.057	1.063
Pennsylvania No. 3.....	7 per cent pitch B.....	1.24,	1.28,	1.296	1.28
Do.....	7 per cent pitch B and 9 per cent West Virginia No. 3.....		1.186,	1.163	1.174
Wyoming No. 1.....	8 per cent pitch H.....	.95,	.98,	.99	.98
Coke breeze (strong briquettes).....	8 per cent pitch D.....	1.03,	1.02		1.025
Coke breeze (weak briquettes).....	do.....	1.001,	1.004		1.002

WEIGHT OF BRIQUETTES.

In order to ascertain the average weight of each lot of briquettes made on the English machine, 24 of each lot were selected, 1 from each wheelbarrow full, as they were taken from the platform to be piled in the yard. These 24 were weighed and the average of these was taken to represent the average weight of that particular run of briquettes.

WEATHERING.

In order to make a definite comparison of the weathering properties of the briquettes, the 24 of each lot that were weighed in determining the average weight of the briquettes were piled up side by side in a fenced-off portion of the yard to be left during the winter. Some of these had already been standing exposed to the weather for over two months and others for a month.

The subsequent report of Prof. A. A. Steel shows the conditions of samples of the various briquettes after one winter's exposure to the weather.

On April 10, 1911, the briquettes made last fall were found to be in the following condition after exposure to the weather throughout the winter:

Briquettes No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24. Considerably eroded upon exposed surfaces owing to the rain washing away the fine particles of coal. Briquettes made.

Briquettes No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24. Slightly eroded and much of the surface is smooth.

Briquettes No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24. Slightly eroded and much of the surface is smooth.

Briquettes No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24. Very little erosion and surface is smooth.

Briquettes No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24. These briquettes show no apparent change after one winter.

Briquettes No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24. These briquettes show no apparent change after one winter.

Briquettes No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24. These briquettes show no apparent change after one winter.

Briquettes No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24. These briquettes show no apparent change after one winter.

Briquettes No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24. These briquettes show no apparent change after one winter.

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Briquettes No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24. These briquettes show no apparent change after one winter.

"Indian Territory No. 6: 7 per cent pitch D. Eroded on the outside of the pile, but fairly strong inside.

"Indian Territory No. 6: 9 per cent pitch D. Somewhat eroded, but the inner briquettes seem to be stronger than when first made.

"Indian Territory No. 6: 8 per cent pitch A. Badly eroded and very crumbly.

"Indian Territory No. 6: 6 per cent rosin, 1 per cent lime. Somewhat eroded, corners very earthy, color darker gray than when fresh, and strength a little greater.

"Indian Territory No. 6: 6 per cent rosin, 1 per cent Kansas petroleum. Badly eroded, but tough and strong.

"Indian Territory No. 6: 8 per cent pitch G (1½ per cent creosote). Slightly eroded, but firm and strong; strong odor of creosote upon breaking.

"Indian Territory No. 6: 8 per cent asphalt B5. Briquettes unchanged in appearance, but seemingly stronger.

"Indian Territory No. 6: 8 per cent pitch H. Briquettes excellent; no change except a slight loss of luster.

"Iowa No. 4: 8 per cent pitch E. Slightly eroded on top of pile; some white efflorescence at base of pile; briquettes strong.

"Iowa No. 5: 8 per cent pitch E. Badly eroded; much white efflorescence.

"Iowa No. 5: 7 per cent pitch E. So much eroded that the coarse grains lie loose on top and are exposed on outer edges of pile; corners very weak and great amount of white coating.

"Kentucky No. 1: 6 per cent pitch D. The more porous of the briquettes are slightly eroded, but the others are still perfect and glossy.

"Kentucky No. 3: 8 per cent and 9 per cent pitch E. Both are unchanged.

"Montana No. 1: 7 per cent pitch B. Slightly eroded, but otherwise perfect.

"Montana No. 1: 9 per cent pitch B. Some briquettes slightly eroded, others perfect.

"New Mexico No. 1: 8 per cent pitch D. Somewhat eroded; briquettes light and brittle.

"New Mexico No. 1: 10 per cent pitch D. Same amount of erosion, but more strength.

"New Mexico No. 1: 8 per cent pitch H. Briquettes perfect.

"New Mexico No. 2: 11 per cent pitch X. Briquettes reduced to earthy rounded lumps.

"New Mexico No. 2: 7 per cent pitch D. All fine material on the surface washed out and corners very crumbly.

"New Mexico No. 2: 9 per cent pitch D. Badly eroded, but a little better than last lot.

"Pennsylvania No. 3: 9 per cent West Virginia No. 3, 7 per cent pitch B. Slightly eroded on the surface.

"Pennsylvania No. 3: 7 per cent pitch B. Considerably eroded, but still strong.

"West Virginia No. 6. All of these with 5 per cent pitch D, 5 per cent pitch Y, or 3 per cent pitch Y have been almost unaffected, still retaining their glossy

appearance. Of each sort there are a few of the more porous briquettes that show a little erosion.

"Wyoming No. 1: 9 per cent pitch H. These show no pitting at all, but the more exposed briquettes have scaled off at the corners, due to decrepitation of the lignite. The inner ones are perfect.

"Wyoming No. 1: 8 per cent pitch H. Considerably eroded; somewhat disintegrated, due to porosity and frost, and scaled slightly, due to imperfect drying of lignite before briquetting.

"Wyoming No. 1 (dried): 5 per cent Wyoming asphalt, $2\frac{1}{2}$ per cent rosin, 1 per cent lime. These are badly disintegrated.

"Coke waste, with 20 per cent West Virginia No. 6 and 7 per cent pitch Y and with 8 per cent pitch D alone. These have lost their metallic sheen and some of the looser fragments of coke which were crushed in pressing have washed out. Some briquettes are perfect.

"Texas lignite (Woodhead's): 19 per cent pitch X. These are weathered to rounded lumps of earthy material.

"Same with 3 per cent pitch A extra. These are also eroded and rounded, but still have some shape and strength."

BRIQUETTES MANUFACTURED.

According to the results obtained in the laboratory briquettes in quantity were made on either the English or the American machine from the following coals:

LIST OF COALS BRIQUETTED.

- (1) Alabama No. 1. Bituminous lump and nut coal from mine No. 8 of the Ivy Coal and Iron Company, Horse Creek, Ala.
- (2) Arkansas No. 1. Bituminous lump and nut coal from mine No. 3 of the Central Coal and Coke Company, Huntington, Ark.
- (3) Arkansas No. 2. Bituminous lump coal from mine No. 12 of the Central Coal and Coke Company, Bonanza, Ark.
- (4) Arkansas No. 3. Bituminous lump and slack coal from mine No. 18 of the Western Coal and Mining Company, Jenny Lind, Ark.
- (5) Arkansas No. 4. Semibituminous slack coal from several Arkansas mines, furnished by the Western Coal and Mining Company, St. Louis, Mo. The coal came principally from mines 1, 2, 3, and 4, near Denning, Ark.
- (6) Arkansas No. 5. Semibituminous lump and slack coal from mine No. 4 of the Western Coal and Mining Company, Coal Hill, Ark.
- (7) Arkansas No. 6. Bituminous slack coal from mine No. 18 of the Western Coal and Mining Company, Jenny Lind, Ark. This is from the same mine as Arkansas No. 3.
- (8) Colorado No. 1. Run-of-mine black lignite from the Simpson mine of the Northern Coal and Coke Company, Lafayette, Colo.
- (9) Illinois No. 1. Bituminous lump and nut coal from mine No. 1 of the Western Anthracite Coal and Coke Company, near O'Fallon, Ill.
- (10) Illinois No. 4. Bituminous lump coal from mine No. 3 of the Donk Brothers Coal and Coke Company, Troy, Ill.

- (11) Indiana No. 1. Bituminous run-of-mine coal from the Mildred mine of the J. Woolley Coal Company, Mildred, Ind.
- (12) Indiana No. 2. Bituminous run-of-mine coal from the Electric mine of the T. D. Scales Coal Company, Boonville, Ind.
- (13) Indian Territory No. 2. Bituminous run-of-mine coal from mine No. 8 of the Rock Island Coal Company, Hartshorne, Ind. T. •
- (14) Indian Territory No. 3. Bituminous run-of-mine coal from mine No. 1 of D. Edwards & Son, Edwards, Ind. T.
- (15) Indian Territory No. 6. Bituminous slack coal from mine of the Southwestern Development Company, Coalgate, Ind. T.
- (16) Iowa No. 4. Bituminous lump coal from mine No. 3 of the Centerville Block Coal Company, Centerville, Iowa.
- (17) Kansas No. 2. Bituminous lump, nut, and slack coal from mine No. 11 of the Western Coal and Mining Company, Yale, Kans.
- (18) Kentucky No. 1. Bituminous run-of-mine coal from Straight Creek mine No. 2 of the National Coal and Iron Company, Straight Creek, Ky.
- (19) Kentucky No. 2. Bituminous lump, nut, and pea coal from mine No. 11 of the St. Bernard Mining Company, Earlington, Ky. •
- (20) Missouri No. 1. Bituminous run-of-mine coal from New Home mine No. 1 of the New Home Coal Company, Sprague, Mo.
- (21) Montana No. 1. Washed bituminous coal from mine near Red Lodge, Mont.
- (22) New Mexico No. 1. Black lignite from Weaver mine of the American Fuel Company, 3 miles north of Gallup, N. Mex.
- (23) New Mexico No. 2. Black lignite slack from the Otero mine of the Caledonian Coal Company, 2 miles east of Gallup, N. Mex.
- (24) North Dakota No. 1. Run-of-mine brown lignite from Lehigh, N. Dak.
- (25) Pennsylvania No. 3. Anthracite culm from Pennsylvania Coal Company, Scranton, Pa.
- (26) West Virginia No. 6. Bituminous run-of-mine coal from mine of the New River Smokeless Coal Company, Rushrun, W. Va.
- (27) Wyoming No. 1. Black lignite from mine of the Wyoming Coal and Mining Company, located at Monarch, Wyo.

The above coals have been tested with various binders on both the English and American machines, and from 1 to 15 tons of briquettes have been made from each coal. In the following pages are given descriptions of the binders used, of the character of the briquettes as they were received from the machine and after they were exposed to the atmosphere, and of their behavior when burned. These descriptions are taken up alphabetically by States.

ALABAMA.

Alabama No. 1.—This is a coking coal which can be very readily manufactured into a briquette with hard pitch and which, under extreme pressure, can be briquetted without the addition of any binder. There were 4.5 tons of this coal briquetted on the English machine with 7 per cent of the hard pitch A. The briquettes were strong and quite satisfactory, except for porosity due to a lack of sufficient pressure. These briquettes stand up well in the fire, but on long

exposure to the weather disintegrate somewhat. The weight of the briquettes averaged 5½ pounds each.

A steam test was made of these briquettes with the following results, the results of the steam test with the original coal being given for comparison:

Results of steam tests on Alabama No. 1 coal and briquettes.

Fuel.	Chemical composition.					Duration of trial.	Total coal consumed.	Horsepower developed by boiler.	Dry coal burned per square foot of grate surface per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horsepower hour.	Dry coal per electrical horsepower hour.
	Fixed carbon.	Volatile matter.	Moisture.	Ash.	Sulphur (separately determined).							
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Hours.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.
Briquettes.....	50.96	33.00	2.63	13.41	0.94	8.25	6,521	196.6	18.97	8.81	3.21	3.96
Nut coal.....	52.52	31.00	2.56	13.92	.78	10.03	8,656	205.8	20.72	8.44	3.35	4.14

ARKANSAS.

All of the Arkansas coals tested are similar in their properties. They are higher in fixed carbon than the ordinary bituminous coal and are often called semianthracite coals. The coals from Jenny Lind and Denning show more of this semianthracite character than the coals from the other sections of Arkansas.

Arkansas No. 1.—This coal was tested only with hard pitch A, as this was the only pitch available at the time the coal was briquetted. Six tons of coal were mixed with 9.25 per cent of this pitch and made into briquettes on the English machine.^a The briquettes were compact and well pressed, but were too friable for handling, showing that they contained insufficient pitch. They were brownish in color and very dirty. Judging from the results obtained in working with other Arkansas coals, this coal will require more than the usual amount of pitch.

A sufficient quantity of this coal was formed into briquettes with which steam tests were made. The results of steam tests of this coal, which was in large lumps, and of the briquettes are given in the following table:

Results of steam tests on Arkansas No. 1 coal and briquettes.

Fuel.	Chemical composition.					Duration of trial.	Total coal consumed.	Horsepower developed by boiler.	Dry coal burned per square foot of grate surface per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horsepower hour.	Dry coal per electrical horsepower hour.
	Fixed carbon.	Volatile matter.	Moisture.	Ash.	Sulphur (separately determined).							
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Hours.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.
Briquettes.....	67.65	21.21	0.94	10.20	1.73	10.03	7,700	206.4	18.74	9.37	3.02	3.73
Lump coal.....	66.36	18.61	1.99	13.04	1.21	10.07	7,071	180.5	16.90	9.05	3.12	3.86

^a For steam test, see pp. 353-360.

Although the actual steam test of these briquettes was satisfactory and they showed up well against the coal, yet the briquettes could not be considered a commercial product on account of their friability.

Arkansas No. 2.—This coal was tested with the hard pitch X, which at the time was the only pitch available. The briquettes were made in the English machine. Six tons of crushed lump coal were run through the machine, which was set to give approximately 11 per cent pitch, but the briquettes were pitchy and wrinkled and probably contained nearer 15 per cent than 11 per cent pitch.^a On account of the difficulty of setting the machine to feed accurate proportions of pitch to the coal, the experiments after this were conducted for the most part by weighing out the desired quantities of coal and pitch by hand. Pitch X, on account of its hardness, set too quickly in the molds, so that the briquettes were insufficiently pressed and consequently porous.

Although they were not commercial briquettes, a steaming test was made with them. The results of this test and of the steaming test with the original coal are given in the table below:

Results of steaming tests on Arkansas No. 2 coal and briquettes.

Fuel.	Chemical composition.					Duration of trial.	Total coal consumed.	Horsepower developed by boiler.	Dry coal burned per square foot of grate surface per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horsepower hour.	Dry coal per electrical horsepower hour.
	Fixed carbon.	Volatile matter.	Moisture.	Ash.	Sulphur (separately determined).							
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Hours.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.
Briquettes.....	60.30	22.49	4.88	12.33	1.32	9.98	7,370	190.3	17.31	9.31	3.00	3.71
Lump coal.....	73.65	16.86	1.07	8.42	1.95	10.07	6,517	180.6	15.70	9.73	2.91	3.59

The greater percentage of volatile matter in the briquettes is due to the large amount of pitch used in them.

Arkansas No. 3.—This coal was briquetted with 9.5 per cent of the hard pitch X, this proportion having been found to be satisfactory for this coal. The coal was slightly moist, and was in just the right condition to pass readily through the machine without clogging the elevator. As the coal was friable it was reduced almost to a flour in the disintegrator. The briquettes had smooth, polished surfaces, having been subjected to the greatest pressure possible with the machine. Some of the briquettes, as delivered by the machine, showed cracks perpendicular to the pressure, which may have been due to an excess of pressure. These briquettes weighed on an average 6.8 pounds each.

^a For steam test, see pp. 369-376.

This coal was also tested with the somewhat softer pitch A. One ton of the coal was mixed with 8.7 per cent of pitch. A large excess of steam was introduced into the pug mill so as to soften the pitch as much as possible. The briquettes were smooth and easily handled, but somewhat pitchy, showing an excess of pitch. Under the same conditions of heat and pressure, 7.5 per cent of pitch A would have been sufficient, and if pitch of proper grade were used a still smaller amount would make a good commercial briquette. These briquettes ignited readily and did not disintegrate in the fire until they were consumed.

The results of the steaming test with these briquettes, together with that made with the original coal, are given below:

Results of steaming test of Arkansas No. 3 coal and briquettes.

Fuel.	Chemical composition.					Duration of trial.	Total coal consumed.	Horsepower developed by boiler.	Dry coal burned per square foot of grate surface per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horsepower hour.	Dry coal per electrical horsepower hour.
	Fixed carbon.	Volatile matter.	Moisture.	Ash.	Sulphur (separately determined).							
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Hours.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.
Briquettes.....	62.04	17.35	2.60	18.01	1.41	10.08	8,600	200.8	20.49	8.34	3.39	4.19
Coal, mine run.....	72.74	16.04	1.97	9.25	1.29	10.02	8,158	219.7	19.68	9.50	2.98	3.68

Arkansas No. 4.—This consisted of slack coal, which was soaking wet when received, and had to be passed through the drier before it could be used. When dried, it was so brittle that the disintegrators of the English machine reduced it to flour, which choked up the elevator and other parts of the machine. The first run made of this dried coal contained 12 per cent of hard pitch X, and although the briquettes when first received from the machine were compact and smooth, they were incoherent and unsatisfactory, and on exposure to the weather became friable and soon began to disintegrate. The next test on this finely divided coal was with pitch A. One ton was mixed up with 10 per cent of pitch. The press was run faster, not only to increase the pressure, but also to give the hard pitch less time to set in the machine. At the same time the speed of the disintegrator was reduced in order not to pulverize the coal so completely. The briquettes were pitchy, and owing to the excess of water from condensation many cracked when the pressure was relieved. Another ton of coal with 8 per cent of pitch A was found to contain too much binder, and another ton was made with 6 per cent. The latter briquettes were compact and well pressed, but did not contain enough binder. Seven per cent of pitch A gave a better result than either 6 or 8.

Another run of this coal was made with 3 per cent rosin and 2 per cent of pitch A. The briquettes were clean and sharp in outline, but were somewhat brittle and had a tendency to break into large fragments. They were, however, physically

better than those with 6 or 8 per cent of pitch alone. In burning, they held together well, but smoked more than those with pitch alone. No odor of rosin was given off, however. This same mixture was tested on the American machine, which gave clean, polished briquettes, which were stronger than those made on the English machine, indicating that rosin works to better advantage in the smaller and more rounded briquettes. With pitch alone, however, and Arkansas No. 4 coal, a stronger briquette was made on the English machine than on the American. The weight of the briquettes made with rosin averaged 6.87 pounds each.

A ton of this coal was briquetted with 3 per cent of rosin and 3 per cent of pitch A. This made excellent briquettes, which were unusually clean and with sharp edges. They weighed 6.87 pounds each. This mixture was also tried on the American machine and gave exceedingly smooth and lustrous eggettes, which were stronger than the large briquettes made on the English machine. Although no boiler test was made on these briquettes, some of them were thrown under the boiler, where they burned very readily without disintegration until consumed. The eggettes were tested in a cook stove, where they burned satisfactorily without any odor, but gave off considerably more smoke than either coal or briquettes made from pitch alone as a binder. The specific gravity of these briquettes was 1.13, while the specific gravity of the coal was 1.35. Their compression or crushing strength was 8,780 pounds, or 306 pounds per square inch.

This coal was further tested with the softer pitch B, which was one of the better pitches for briquetting. One ton was first made with 6 per cent of pitch, and the briquettes were clean, sharp, and apparently considerably stronger than the original lump coal. These were the first commercial briquettes made at the plant. They were capable of standing rough handling. In weight they averaged 7 pounds each, and their specific gravity was 1.17. On the American machine this same mixture gave polished eggettes, but they were not so strong as those made on the English machine. Pitch B was then tried with rosin, the proportions being 95 per cent of coal, 3 per cent rosin, and 2 per cent pitch. On account of the condensation of steam in the pug mill, there was considerable excess of water in the briquettes, which, however, were smooth and sharp when received from the press. The excess of moisture caused them to crack badly, and they were difficult to handle while fresh. After cooling, they were still soft, and they were noticeably inferior to the briquettes made with 3 per cent of rosin and 2 per cent of pitch A. They weighed 7.2 pounds each. This mixture also was tested on the American machine, which made harder eggettes than the corresponding briquettes of the English machine. This is a further confirmation of the supposition that the smaller and rounder form is better adapted for the rosin binder and will result in a harder and tougher briquette.

The manufacture of briquettes from Arkansas No. 4 coal and 6 per cent of pitch B as a binder is commercially feasible. Six tons of this coal were briquetted with 6 per cent of pitch B, with which to make a steaming test.^a Some of these briquettes were made by running one side of the disintegrator of the English machine, and as they were received from the machine they were smooth and uniform but soft. On breaking them open it was found that in spots they contained an excess of pitch, indicating that the materials had not been thoroughly mixed or that in passing from the pug mill to the press there had been an opportunity for the pitch to flow together. On cooling, however, these briquettes became hard and tough. Another ton was made, running both sides of the disintegrator, which made smooth, uniform briquettes, but it was almost impossible to handle them as they came from the machine. Therefore, only one side of the disintegrator was used, but the materials were run through the pug mill more rapidly and better results were obtained. On becoming thoroughly cold, all of these briquettes were excellent in every respect. When these mixtures were tried on the American machine, the fine mass obtained by running both sides of the disintegrator made better eggettes than the corresponding briquettes of the English machine, while the coarser material did not make as good eggettes as briquettes. The weight of the briquettes obtained in running both sides of the disintegrator was 6.92 pounds each, while the coarser briquettes weighed 6.56 pounds each. The specific gravity of these briquettes was 1.17 and their crushing strength was 17,500 pounds, or 610 pounds per square inch.

The results of the steaming test of these briquettes are given in the table below:

Results of steam test of Arkansas No. 4 briquettes and eggettes.

Fuel.	Chemical composition.					Duration of trial.	Total coal consumed.	Horsepower developed by boiler.	Dry coal burned per square foot of grate surface per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horsepower hour.	Dry coal per electrical horsepower hour.
	Fixed carbon.	Volatile matter.	Moisture.	Ash.	Sulphur (separately determined).							
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Hours.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.
Briquettes.....	71.98	14.06	3.85	10.11	1.64	9.95	8,142	214.5	19.41	9.40	3.01	3.72
Eggettes.....	66.03	18.60	3.18	12.19	1.70	7.03	5,238	166.8	17.78	7.98	3.54	4.38

Arkansas No. 5.—On account of the success obtained with these Arkansas coals and the softer pitches, it was decided to make a sufficient quantity of briquettes for a locomotive test on the Missouri Pacific Railway. For this purpose 17 tons of Arkansas No. 5 coal were briquetted with 6 per cent of pitch C, which was a trifle harder than pitch B. Excellent briquettes were obtained, which were

^a For steaming test see pp. 394-406.

readily handled while warm, and on cooling stood a good deal of rough handling. They did not break so readily as the original lumps of coal. The briquettes were tested on a locomotive of the Missouri Pacific Railway, and for comparison similar runs were made on an Illinois run-of-mine coal such as is commonly used on these locomotives. Three trips were made from St. Louis to Washington, Mo., and return, making a total run of 324 miles for each fuel. The results of these three runs are given in the tables following:

Locomotive test of briquettes of Arkansas No. 5 coal.

Date.	Bri- quettes con- sumed.	Ash removed.	Front-end cinders removed.	Total coal con- sumed.	Total ash removed.	Per cent of ash.	Miles to ton.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>		
November 28.....	9,720	1,250	194	29,594	4,615	15	21.89
November 29.....	10,049	1,535	182				
November 30.....	9,825	1,226	228				

Locomotive test of run-of-mine Illinois coal.

December 1.....	11,265	1,980	130	34,015	5,695	16.4	19.05
December 2.....	11,050	1,558	112				
December 3.....	11,700	1,800	115				

As is seen from the above tables, the briquettes gave better results than the Illinois coal, indicating that by briquetting even an inferior coal it is possible to obtain a fuel that is superior not only to the original coal but to good coals. Mr. L. Bartlett, one of the master mechanics of the Missouri Pacific Railway, under whose general direction these tests were conducted, made the subjoined statement in regard to the size of the briquettes:

“The briquettes are too large for locomotive use. They must be thrown indiscriminately into the fire boxes, and if they take position side by side the flame can not get to them. If, on the other hand, they lie in irregular positions, the space may be too large between them, which has a bad effect by allowing too much cold air to pass. In fact, the engine does not steam well until they are broken.”

The size of the briquettes has always been considered too large, and in all the steaming tests made at the testing plant they were broken up before they were fed to the boiler, and tests were made of the briquettes as to the amount of fines they made when broken up.

Mr. Bartlett also noted the amount of smoke given off by this coal, and stated that one advantage in the briquetted fuel was that it could be called a smokeless fuel, as compared with Illinois coal. This, of course, would be a considerable advantage when used on switching engines in city freight yards.

The sulphur content of this coal is rather high, as may be seen from the analysis given on page 202, and this was of course also true of the briquettes. This sulphur would naturally attack the grate bars, so that briquettes made of this coal would have a more injurious effect on the grate bars than coals containing less sulphur. This was true in the above locomotive tests, the Arkansas No. 5 coal attacking the grate bars much more than the Illinois coal.

The larger number of briquettes used on November 29, as shown in the above table, was due to the delay of the train at Choctaw avenue crossing, where three or four hours were lost because the wires of the street-railway company were down.

A further test of Arkansas No. 5 coal was made by mixing one-fourth of the soft pitch C and three-fourths of the hard pitch A, a combination which made a good briquette, but not so good as that made with 6 per cent of pitch C. With more than three-fourths of hard pitch, it was necessary to use more steam for heating and greater pressure, and the resultant briquettes were considerably inferior and more crumbly.

Arkansas No. 6.—This coal was briquetted with 8 per cent of pitch A and made a briquette of fair quality. These briquettes were made in order to test the coking value of the mixture, and this work is described on pages 1331–1332 and 1454.

COLORADO.

Colorado No. 1.—The only coal tested from Colorado was a black lignite, which was first used undried with 10 per cent of pitch D. As these briquettes were received from the machine they were hard to handle, especially when there was an excess of steam. The pitch did not seem to adhere to the grains of lignite. On cooling, however, they became hard, black, and lustrous, but were too brittle. The adhesion of the pitch to the grains of lignite was not strong. The briquettes seemed to be too pitchy, and if the adhesion between the pitch and lignite were greater 8 per cent would undoubtedly be sufficient to give the desired results. Although there was no steam test made with these briquettes, they were burned under one of the boilers, and proved quite satisfactory. They weighed 5.98 pounds each. Some of the same mixture was tested on the American machine, but the eggettes were much inferior to the briquettes.

ILLINOIS.

Illinois No. 1.—Briquettes from this coal were first made with the hard pitch X as a binder. One and a quarter tons of this coal were briquetted with 16 per cent of pitch X, but on account of the softness and roughness of the coal the briquettes were brown and soft, resembling pressed damp loam. They were, however, compact and well pressed.

Illinois No. 4.—Two tons of this coal were briquetted with 6 per cent of pitch D. The coal was not finely ground, only one side of the disintegrator being used. There was a great deal of water in the steam, and the briquettes were full of the usual perpendicular cracks. A high pressure was used, and some of the briquettes were larger than the normal size, a fact which was due to the compression of the spring of the machine. The average weight of these briquettes was 6.95 pounds. The briquettes varied considerably in texture, some being hard and firm, while others were crumbly. On cooling, the briquettes were hard and firm, but would not stand much rough handling. The specific gravity of these briquettes was 1.16, and their crushing strength was only 5,100 pounds, or 181 pounds to the square inch. Some of these mixtures were also tried on the American machine, and the eggettes were better than the briquettes made on the English machine. They were lustrous and had a deep black color.

One ton of this coal was briquetted with 8 per cent of pitch D, only one side of the disintegrator and the maximum pressure being used. Excellent briquettes were obtained with this combination, but they were gray in color. They weighed 6.43 pounds each and had a specific gravity of 1.11. The specific gravity of the coal is 1.34. The crushing strength of these briquettes was 9,327 pounds, or 325 pounds per square inch, as compared with 181 pounds to the square inch when 6 per cent pitch D was used as a binder. The eggettes made of this mixture on the American machine were not so strong as the briquettes.

The next test made with Illinois No. 4 consisted of 2 tons of the coal briquetted with 8 per cent of pitch E. The average weight of the briquettes was only 6.15 pounds. Only one side of the disintegrator was used, and as the coal was hard the briquettes were coarse and contained many noticeably large pieces of coal. The eggettes made from this mixture, on the other hand, were much better in quality and rather lustrous, but of a decidedly brownish color. The specific gravity of these briquettes was 1.13 and their crushing strength 7,265 pounds, or 253 pounds to the square inch. To test the effect of finer grinding, another ton of this coal was briquetted with 8 per cent of pitch E, both sides of the disintegrator being used. In these briquettes there were a few grains of coal as big as a kernel of corn; but for the most part the material was too fine for the percentage of pitch, and the resultant briquettes were crumbly, although well

pressed, black, and lustrous. They weighed on an average 6.5 pounds each and had a specific gravity of 1.03. Their crushing strength was only 209 pounds to the square inch. There was little difference in the properties of the eggettes and the briquettes made of this mixture. Another ton of this coal was briquetted with 9 per cent of pitch E, both sides of the disintegrator and a maximum pressure being used, with the result that a briquette of much better quality was obtained. They could, however, have been still further improved by the addition of another one-half per cent of pitch. The weight of these briquettes was 6.43 pounds each and their specific gravity was 1.08. Their crushing strength was 9,125 pounds, or 352 pounds to the square inch. The eggettes made from this mixture were equal in strength and quality to the briquettes and were much more lustrous and bluish black in color.

Another test was made with Illinois No. 4 coal and pitch H, which is a by-product from the manufacture of gas from heavy petroleum. While this pitch would be rather soft to work on the English machine on a hot day, it is readily cracked and mixed on a cold day. One ton of the coal was briquetted with 8 per cent of pitch H, and the briquettes were strong, clean, and satisfactory, being much better than any of the other briquettes made with this coal. They were readily handled when taken from the machine, and when cold were hard and tough, and capable of standing a great deal of rough handling. Their average weight was 6.81 pounds each and their specific gravity was 1.11. Their crushing strength was 12,810 pounds, or 446 pounds to the square inch, this being the hardest of all the briquettes made from Illinois coal.

The last test made with this coal was with a soft asphalt received from the Gulf Refining Company. In freezing weather this asphalt became hard enough to crack and could then be used on the English machine. On account of the cold weather there was considerable water in the steam, which produced cracks. Because of this fact and the low melting point and thinness of the asphalt while hot, the briquettes were difficult to handle as they came from the machine. They were, however, well pressed and on cooling became tough and would stand much handling. The weight of these briquettes was 6.77 pounds each. A better result can probably be obtained by using a small percentage of rosin with the asphalt.

INDIANA.

Two coals from this State were tested more for comparative purposes than with regard to their commercial possibilities.

Indiana No. 1.—Four tons of this coal were briquetted with 7 per cent of pitch D.^a The coal was first washed and then dried. The briquettes were

^a For steaming test see pp. 473-480.

brown in color, readily handled as they came from the machine, and when cold stood rough handling. The average weight of the briquettes was 6.8 pounds each. The eggettes of this mixture, made on the American machine, were better and stronger than the briquettes.

The results of a steaming test of these briquettes are given, together with similar results of the original coal, in the table below:

Results of steam test of Indiana No. 1 coal and briquettes.

Fuel.	Chemical composition.					Duration of trial.	Total coal consumed.	Horsepower developed by boiler.	Dry coal burned per square foot of grate surface per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horsepower hour.	Dry coal per electrical horsepower hour.
	Fixed carbon.	Volatile matter.	Moisture.	Ash.	Sulphur (separately determined).							
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Hours.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.
Briquettes.....	43.23	38.79	11.74	6.24	2.03	6.60	6,579	222.6	21.70	8.73	3.24	4.00
Nut coal, washed.....	40.41	35.17	16.59	7.83	2.18	9.93	10,819	222.7	22.39	8.45	3.34	4.13

As is seen from the above table, there is a slight advantage in efficiency in favor of the briquettes.

Indiana No. 2.—One ton of this coal was briquetted with 7 per cent of pitch H, and the briquettes were satisfactory in every way. They were brown in color and resembled those made of Indiana No. 1 coal, but were much stronger, by reason of the better quality of pitch. They weighed on the average 6.42 pounds each.

INDIAN TERRITORY.

Indian Territory No. 2.—This coal was tested with the hard pitch X, first with 8.5 per cent of pitch, but the briquette was not strong and crumbled readily. With 12 per cent of pitch the briquettes were not much better, and with 13.4 per cent the briquettes looked well as they came from the press, but were not strong and began to lose their corners soon after being exposed to the weather. Judging from the runs made this coal will require more than the usual pressure. The briquettes containing 8.5 per cent of pitch weighed only 5.08 pounds each. Those with 13.4 per cent of pitch weighed 6.15 pounds each.

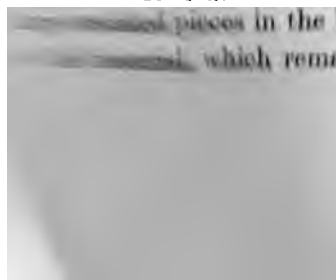
Indian Territory No. 3.—This coal, which is hard and glossy, was tested on the English machine with 8 per cent of pitch A. This made fairly good briquettes, which were clean and hard, although somewhat porous, but they were not so strong as was desired. This defect was due in part to lack of sufficient heat to soften the pitch thoroughly in the pug mill. The briquettes as received from the machine weighed 6.56 pounds each. With 7.2 per cent of pitch A, this coal made smooth and fairly hard briquettes, which weighed 6.71 pounds each. With 6 per cent of pitch A, briquettes were made of this coal that were smooth and well pressed,

but soft. These averaged in weight 6.8 pounds each. If this pitch could have been heated in the English machine to a temperature sufficiently high to cause it to soften and mix with the coal it would undoubtedly have made a good briquette. This is indicated by the fact that with a soft pitch, as pitch D or pitch H, this coal could be briquetted with 6 per cent. of binder.

Indian Territory No. 6.—This sample consisted of a carload of dirty slack, which contained considerable fire clay and some shale. Laboratory experiments had shown that 7 per cent of a binder of the quality of pitch D was the minimum that could be expected to give satisfactory results. Accordingly, one ton of this coal was mixed by hand with 7 per cent of pitch D, but the briquettes were crumbly and not at all satisfactory, although dense and well pressed. They weighed 7.35 pounds each. They were full of gray streaks on the surface, due to the fire clay, and on standing became coated with a heavy gray efflorescence, which was tested and proved to be calcium sulphate. Eggettes of this same mixture made on the American machine were practically the same in character and unusually dull grayish in appearance. The specific gravity of these briquettes was 1.205. When tested upon the compression machine these briquettes, which were crumbly and weak and broke easily in the fingers, compressed much more than usual before breaking. Their crushing strength was 5,600 pounds, or 195 pounds per square inch. Another ton was tried with 9 per cent of pitch D, but the briquettes were practically the same as with 7 per cent, although a little darker in color. They also showed similar streaks of fire clay on the surface and their fracture was decidedly earthy. They weighed on the average 7.5 pounds each. There seems to be little adhesiveness between this pitch and the dirty coal, and to make a good briquette with this pitch it would be necessary to use probably as much as 15 per cent, if not more.

Satisfactory results with soft pitch not having been obtained, one ton of this ~~dark~~ coal was tried with 8 per cent of the harder pitch A. The briquettes were ~~well pressed~~ and blacker than those with 7 per cent of pitch D, but were not so ~~strong~~. The mixture did not show any tendency to stiffen in the machine. All ~~of the tests~~ with this coal demonstrated its injurious effect on the binding properties ~~of the pitch~~.

~~This coal~~ was next tried by mixing together 93 per cent of coal, 6 per cent of ~~lime~~ and 1 per cent of quicklime. The lime was mixed in sizes ranging from ~~three-fourths~~ three-fourths of an inch in diameter, and it was thought that the ~~pieces~~ ~~would be reduced~~ by the disintegrator and the lime slaked by the steam ~~so that the cement would not set too quickly~~. The disintegrator, ~~however, had little effect~~ on the hard lime, and consequently there were many ~~pieces~~ in the briquettes, which caused them to fall to pieces. Some ~~pieces~~ which remained in the pug mill for some time, gave a briquette



which was hard while hot, but which after cooling became earthy. These briquettes weighed on an average 7 pounds each. The eggettes made of this material were dense, but crumbly.

In order to prevent unslaked lime from going into the briquettes, the lime was slaked before using with one-half its weight of water, making a fine, dry powder. This was mixed with the coal to give the same proportions with the rosin as in the above test, and although the briquettes were smooth and well formed, having been thoroughly pressed, they were crumbly and not at all strong. They were grayish in color and similar in quality to those made with 7 per cent pitch D. They weighed on an average 7.5 pounds each. The eggettes of this same material were also crumbly and dull in luster.

Some of these lime-rosin briquettes were burned and were found to give less smoke than those with the rosin and no lime, and some less even than those with pitch alone.

Another test of this coal was made with rosin and Kansas crude oil. The experiments in the laboratory had shown that the best results could be obtained by using 6 per cent rosin and 1 per cent of the oil. In preparing this combination for the English machine the oil was first mixed with five times its weight of fine coal, so as to make a nonsticky mass that would readily mix with the cracked rosin and coal in the usual manner. As the rosin became very fluid at 212° F. the hot briquettes when received from the machine had no strength, and cracked slightly under their own weight when piled only two high. They also cracked rather badly owing to the water from the wet steam. On cooling they became strong and were of good quality. Some of the mixture that was allowed to stand in the mold until cool enough to be plastic before pressing was good as received from the machine, but it had not been sufficiently pressed. On standing, these briquettes became coated with a heavy brownish-gray efflorescence. The weight of these briquettes averaged 7.29 pounds each and their specific gravity was 1.25. The crushing strength of the briquettes was on the average 6,400 pounds, or 223 pounds per square inch. On account, however, of the lack of uniformity of the briquettes, the results of eight tests varied from 4,300 to 9,240 pounds. The eggettes made from this same mixture were hard and compact, although of a dull color, and they had a good degree of strength as received from the machine. With an arrangement for cooling the mass after it has passed through the pug mill and before being fed to the press, this mixture would make briquettes which would be very good physically, but which would smoke rather badly.

Since the above tests showed that the best way to counteract the effect of the large amount of fire clay in this coal was to add some liquid binder which would soak into it and yet at the same time unite with the solid binder, another

test was made with creosote as a liquid binder and pitch as the hard binder. For this purpose Indian Territory No. 6 coal was mixed with 8 per cent pitch G and 1½ per cent of creosote, such as is used in preserving timber. The creosote and five times its weight of fine coal were first mixed together and then thoroughly mixed with the cracked pitch and coal. In operating the machine with this mixture the amount of steam used for heating the mixture was gradually increased until there was an excess. This, however, had no effect upon the cooled briquettes, but it made the hotter ones more tender and a little harder to handle. The first briquettes of this mixture cracked a little, because of excess of water, but the remainder came from the machine strong enough to bear handling at once. The effect of the excess of steam was to insure more complete softening of the pitch and more uniform mixing of the clay. These briquettes were black and clean and only slightly streaked with the clay. When piled up they stuck together slightly, and were mottled a little from the creosote. They had, however, much less of the gray efflorescence than any of the Indian Territory No. 6 briquettes and were also the best made, although still earthy. They were smooth and black, and although crumbling little or not at all in handling, they will crumble a great deal on breaking for firing. The eggettes, on the other hand, made of this same mixture on the American machine are just as strong and would need no breaking in firing. The weight of these briquettes was 7.25 pounds each on an average. The specific gravity was 1.215, and their crushing strength was 6,500 pounds, or 226 pounds to the square inch.

Another test with the Indian Territory No. 6 coal was with the asphalt B5, which during the cool weather had become hard enough to crack, and thus could be readily used on the English machine. One ton of this coal and 8 per cent asphalt were used, which made soft briquettes that were hard to handle while warm, especially when they contained moisture due to the wet steam. The better ones were compact, heavy, and tough, and although they had an earthy, oily appearance, did not crack when struck a severe blow. They would stand rough handling, but would be improved with a small percentage of rosin. These briquettes weighed 7.12 pounds each, and had a specific gravity of 1.22. Their crushing strength was very low, averaging 3,200 pounds, or 111 pounds per square inch. In making the compression tests the briquettes yielded a great deal before breaking and would be stronger under a quick load. The crushing strength varied from 1,800 to 5,100 pounds.

In obtaining a sample of pitch H it was decided to try the effect of this pitch on the Indian Territory No. 6 coal. The best results were obtained with this as binder. One ton of coal was mixed with 8 per cent of pitch H, and with nearly atmospheric pressure they made hard, compact briquettes. Although they would stand rough handling. Their average weight was

IOWA.

Iowa No. 4.—One ton of this coal was briquetted with 7 per cent of pitch E. The briquettes were well pressed, of a grayish color, but on cooling crumbled decidedly. They weighed 6.73 pounds each. As they did not contain an excess of pitch, 7 tons more of this coal were briquetted with 8 per cent of pitch E, in order to have a sufficient quantity for a steam test. The resultant briquettes were bluish black in color, but were not quite hard enough, although fairly strong, and would stand considerable rough treatment in transportation. In burning they held together until consumed. They weighed, on an average, 6.77 pounds each. The eggettes made from this same mixture were stronger than the briquettes, had a polished surface, but were very brown in color. In the cook stove they burned satisfactorily, crumbling little until consumed.

The steaming test made of these briquettes gave considerably better results than the original coal, indicating that the coal has been much improved by briquetting. The results of the boiler tests of both the coal and briquettes are given in the table below.

Results of steam test of Iowa No. 4 coal and briquettes.

Fuel.	Chemical composition.					Duration of trial.	Total coal consumed.	Horsepower developed by boiler.	Dry coal burned per square foot of grate surface per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horsepower hour.	Dry coal per electrical horsepower hour.
	Fixed carbon.	Volatile matter.	Moisture.	Ash.	Sulphur (separately determined).							
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Hours.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.
Briquettes.....	37.85	36.50	13.24	12.41	3.90	10.03	9,900	184.5	21.11	7.43	3.80	4.70
Coal, mine run.....	37.28	34.09	13.48	15.15	5.04	10.00	9,385	167.3	20.02	7.11	3.98	4.91

KANSAS.

Kansas No. 2.—Two tons of this coal were briquetted with 11 per cent of pitch X. The pitch of the mixture, in passing through the machine from the pug mill to the press, set so quickly that the briquettes did not receive the necessary pressure. The surface was rough, and a great many cracks were developed. No more of this coal was available for briquetting after receiving pitch of the better qualities. It is, however, a coal that will briquette very readily with pitch of the better grades, such as pitch D or pitch H. It requires about 7 per cent of either for commercial briquettes.

KENTUCKY.

Kentucky No. 1.—This is a good coking coal, unusually light in weight and lustrous. In passing through the disintegrator it was ground a little too fine, even when only one side of the machine was used. Furthermore, on account of its

light weight it was difficult to give it the right pressure on the English machine. The coal was tested with 6 per cent of pitch D, and the briquettes were clean and black, but not sufficiently pressed to close all the pores. They were, however, good briquettes, and would stand rough treatment in transportation. They stood weathering with little change. They weighed on an average 6.15 pounds each. The eggettes made from this same mixture were smooth and lustrous and as strong as any eggettes made on the American machine. In the cook stove they burned satisfactorily without disintegrating or giving off an excess of smoke. This coal can be briquetted readily.

Kentucky No. 2.—As none of the good pitches were available at the time this coal was tested, it was briquetted with 9 per cent pitch E, the percentage determined by laboratory work. Three tons of this coal were tested. The briquettes were extremely pitchy, and on account of the excessive water due to wet steam, were difficult to handle, and when piled three or four deep crushed under their own weight. With dry steam the briquettes were more easily handled. Although still somewhat plastic, they did not crush when piled up. On cooling, the briquettes were hard, with a lustrous fracture, and were capable of standing a great deal of rough handling. These briquettes weighed on an average 6.83 pounds each. The eggettes made of this mixture were hard and sonorous, but rather too brittle. In the cook stove the eggettes burned satisfactorily.

This coal was tested with 8 per cent pitch E, by using 3½ tons of coal and giving the briquettes the greatest pressure possible on the English machine. As the coal is hard, and only one side of the disintegrator was used, there were many large pieces of coal in the briquettes, but there were also sufficient small pieces to fill in all the openings between the larger fragments. This is a nearly ideal condition for briquetting on the English machine. The briquettes were bluish black and excellent in every way. They did not have the glossy or lustrous fracture of the briquettes containing 9 per cent of pitch, but they were a better commercial briquette and were more easily handled when taken from the machine. With pitch of the quality of pitch D or pitch H, from 5 to 6 per cent would make a good briquette. These briquettes would stand a great deal of rough treatment in transportation. They did not disintegrate in burning, nor was there much slack formed in breaking them for burning. They weighed on an average 6.83 pounds each and had a specific gravity of 1.13, as compared with 1.37 for the slack or fine coal. The slack which was used in making the briquettes contained 18 per cent of ash, but the lump coal contained only 11 per cent of ash. The crushing strength of the briquettes was 11,300 pounds, or 394 pounds per square inch.

The results of the steaming test of these briquettes show that the briquettes have no greater efficiency than the original coal. These results are given in the table below.

Results of steaming test of Kentucky No. 2 coal and briquettes.

Fuel.	Chemical composition.					Duration of trial.	Total coal consumed.	Horsepower developed by boiler.	Dry coal burned per square foot of grate surface per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horsepower hour.	Dry coal per electrical horsepower hour.
	Fixed carbon.	Volatile matter.	Moisture.	Ash.	Sulphur (separately determined).							
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Hours.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.
Briquettes.....	44.32	37.07	7.11	11.50	3.71	9.82	9,371	207.1	21.87	8.06	3.51	4.33
Coal, nut.....	45.75	37.91	7.76	8.58	3.37	10.00	9,557	208.5	21.75	8.16	3.47	4.28

The eggettes made from this same mixture were stronger and better than those made with 9 per cent pitch, although not so sonorous and hard. They were also browner in color. The eggettes were not so strong as the briquettes.

MISSOURI.

Missouri No. 1.—At the time this coal was tested only the hard pitch was available. Two and a half tons of this coal that had been previously washed were briquetted with 11.5 per cent of pitch A. The briquettes were black in color and sufficiently hard to stand rough handling, but on account of the pitch setting too quickly they were insufficiently pressed and were granular and porous. This coal will, however, briquette very readily, and with the softer pitches, as pitch D and pitch H, will make a good briquette with about 6 to 7 per cent of binder.

These briquettes were tested under the boiler and the results are given below, together with those of the original coal.

Results of steaming test of Missouri No. 1 coal and briquettes.

Fuel.	Chemical composition.					Duration of trial.	Total coal consumed.	Horsepower developed by boiler.	Dry coal burned per square foot of grate surface per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horsepower hour.	Dry coal per electrical horsepower hour.
	Fixed carbon.	Volatile matter.	Moisture.	Ash.	Sulphur (separately determined).							
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Hours.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.
Briquettes.....	41.85	37.60	6.38	14.17	4.56	5.10	4,500	191.2	20.37	7.99	3.54	4.37
Coal, mine run.....	40.64	34.88	7.28	17.20	4.37	10.00	9,737	207.4	22.30	7.92	3.57	4.41

MONTANA.

Montana No. 1.—This coal was dried slightly before briquetting. It was tested with 16 per cent of pitch A. The full limit of pressure that could be obtained on the English machine was used, and although the briquettes were well pressed they were somewhat porous and rough on the surface. They were black, but not glossy. They stood rough handling, and weighed on the average 6.30 pounds each.

This coal was briquetted with 7 per cent pitch B, the highest pressure obtainable being used. As received from the press, the briquettes were somewhat plastic, but on cooling proved to be brittle. They weighed on an average 7 pounds each.

NEW MEXICO.

New Mexico No. 1.—This black lignite was first briquetted with 12 per cent pitch A, but the briquettes were unsatisfactory in every way. Five and a half tons of this coal were briquetted with 15.8 per cent pitch X, and the briquettes were apparently good in every way and could be handled easily without crumbling. On cooling, however, they began to crumble, and did not weather well. In burning they showed a decided tendency to disintegrate.

This coal was tested on the English machine with 8 per cent pitch D. The briquettes were rather crumbly and earthy, and on cooling were covered with white efflorescence. They did not contain a sufficient quantity of pitch. They weighed on an average 6.83 pounds each and had a specific gravity of 1.13. Their crushing strength was 7,120 pounds, or 248 pounds to the square inch.

As 8 per cent of pitch D did not give any excess of binder, and as the briquettes were not satisfactory, another ton of this coal was tested with 10 per cent of pitch D. While the briquettes fresh from the machine were somewhat stronger than those with 8 per cent of pitch D, it was found that upon standing and becoming thoroughly cool they became so like those made with 8 per cent pitch D that the two could not be distinguished from each other. This indicated that a satisfactory briquette could not be made from this coal with this pitch, even by greatly increasing the percentage. In making these briquettes the English machine was run under ideal conditions, having a constant pressure; the coal was sufficiently dry and not too fine, and could be briquetted at a moderate temperature. The briquettes showed a little more white efflorescence with the 10 per cent than with the 8 per cent pitch D, although they were quite glossy. The average weight of these briquettes was 6.42 pounds each and their specific gravity was 1.02. Their crushing strength was 5,900 pounds, or 206 pounds per square inch, as compared with 248 pounds per square inch for those made with 8 per cent pitch D. The

eggettes were glossy on the surface, but had a dull fracture and were not tenacious. They showed a tendency to disintegrate in burning.

The most satisfactory test was with pitch H, and one ton of this coal was briquetted with 8 per cent of this pitch. The briquettes were hard, strong, and clean—much better in every way than any briquettes of this coal made with pitch D. They weighed on the average 6.25 pounds each and their specific gravity was 1.06. Their crushing strength was 13,050 pounds, or 454 pounds to the square inch, nearly twice the strength of those made with 8 per cent pitch D.

New Mexico No. 2.—This black lignite is almost identical with New Mexico No. 1. It was tested with 9.3, 10.5, and 12 per cent of pitch X, but in every case the briquettes were crumbly and no positive results could be obtained.

This coal was next tested with pitch D as a binder, 1 ton of the coal being briquetted with 7 per cent of pitch D. The briquettes were crumbly, gray in color, and had an earthy fracture. They were neither hard nor strong and were porous, although the limit of pressure was given. There did not seem to be any difference in the briquette, whether made with a low or high pressure. A large amount of grayish efflorescence appeared on the briquettes almost immediately. The briquettes weighed on an average 7 pounds each. The eggettes made from this mixture, although not so porous, had the same earthy appearance and fracture and gray color.

Another ton of this coal was briquetted with 9 per cent of pitch D, and an excess of pitch, due to its partial volatilization, was indicated by the bluish color on the surfaces. On account of an excess of steam, the briquettes were rather soft as received from the machine, and owing to the excess of pitch many of them stuck together. Although they were better than those made with 7 per cent pitch D, they were not commercial briquettes. They weighed on an average 7.12 pounds each. This coal was very dirty and contained considerable clay, and the same difficulties were experienced in briquetting it with pitch as were encountered with the Indian Territory No. 6 coal and pitch. From the work done on this sample it has been definitely proved that such dirty lignites can not well be briquetted with any commercial percentage of pitch as a binder, unless perhaps it is a pitch made from petroleum, as pitch H.

Five tons of this coal were briquetted on the American machine by using 10.25 per cent of the Hoffman patent binder, consisting of petroleum, rosin, and quicklime. These briquettes were not tough, but held together pretty satisfactorily when burned under the boiler.

A steaming test was made of these eggettes and the results, together with those obtained for the original coal, are given in the table below.

Results of steaming test of New Mexico No. 2 coal and eggettes.

Fuel.	Chemical composition.						Total coal consumed.	Horsepower developed by boiler.	Dry coal burned per square foot of grate surface per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horsepower hour.	Dry coal per electrical horsepower hour.
	Fixed carbon.	Volatile matter.	Moisture.	Ash.	Sulphur (separately determined).	Duration of trial.						
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Hours.						
Eggettes.....	39.07	37.56	6.75	16.62	1.61	8.12	7,765	185.8	22.00	7.19	3.93	4.86
Coal, pea.....	36.11	37.30	9.92	16.67	1.13	10.00	11,870	198.5	26.37	6.41	4.41	5.45

NORTH DAKOTA.

North Dakota No. 1.—This is a tough, woody, brown lignite, which does not disintegrate readily. In the first test the lignite was not previously dried and was mixed with 10 per cent of pitch A. Although the highest possible pressure was used, the briquettes were porous and had the appearance of an incoherent mass of chips. With 12 per cent of pitch A the briquettes were still porous and noncoherent, and on standing for some time exposed to the weather the grains and fragments of lignite began to slack off. Between the fragments of lignite there was an excess of pitch observed, but it did not seem to have any adhesion for the fragments. As the briquettes were cooling it was noticed that the contained steam acted upon the lignites, giving them the appearance of lumps of soft, brown loam surrounded by pitch.

The next test was made with dry material, the lignite having been previously ground to about 4 mesh. One ton of this dry, fine material was mixed with 12 per cent of pitch A and run through the English machine, only one side of the disintegrator being used. There was no excess of steam and the full pressure was used, but the briquettes were open. With both sides of the disintegrator in use there was a slight improvement in the briquettes, but they were all porous and incoherent and on exposure to the weather began to disintegrate. There was apparently an excess of pitch between the flakes, similar to that observed in the first ton tested. The same mixtures were tested on the American machine, and the eggettes when first received had a polished, lustrous appearance, but became rough immediately, and they had almost no coherence. This lignite was tested further by increasing the percentages of pitch, allowing the mixtures to remain longer in the pug mill, and increasing the pressure to the limit that could be attained on the English machine, but no briquettes were obtained that had any coherence, and all the results were negative.

PENNSYLVANIA.

Pennsylvania No. 3.—This sample consisted of a carload of anthracite culm. The first test was with 90 parts of the culm and 10 parts of a West Virginia coking coal, and 12½ per cent of hard pitch A. The mixture was run through the English machine, both sides of the disintegrator being used and the briquettes being pressed to the limit of the machine. On account of the hardness of the anthracite coal it did not disintegrate to any great extent and the briquettes resembled concrete. These briquettes were hard and tough, and even with this inferior pitch were of good quality. They weighed on an average 7.25 pounds each. During combustion they burned like lumps of anthracite coal, making but little flame. On standing exposed to the weather the briquettes did not suffer to any extent except during hard rains, when their surfaces became pitted. Apparently this pitting was due to the wearing away of the softer pitch from the harder fragments of anthracite.

This culm was next tested with the softer pitch B, by using 84 per cent of anthracite, 9 per cent of West Virginia coking coal, and 7 per cent of pitch B. For this test the coarsest and driest portion of the anthracite culm was used. This combination made fair briquettes, but they would have been improved if dry steam could have been used. The briquettes weighed on an average 7.64 pounds each and had a specific gravity of 1.174, while the specific gravity of the raw culm was 1.52. The crushing strength of the briquettes was only 4,500 pounds, or 156 pounds to the square inch. The eggettes of this mixture made on the American machine were harder and firmer than the corresponding briquettes. They all burned like anthracite coal, except that in starting the fire they were more easily ignited.

Another ton of the anthracite culm, which had been kiln-dried, was briquetted with 7 per cent of pitch B without the addition of any bituminous coal. If the steam introduced into the pug mill was wet the fresh briquettes were almost too soft to handle. If, however, the steam was dry, they were firm and polished. Although the briquettes were not so lustrous as those made with soft coal, they were clean, smooth, hard, and strong, and when dropped rang like stone. The eggettes of this mixture made on the American machine were also very good, but no better than the briquettes. Both the eggettes and the briquettes burned like lump anthracite, with very little flame or crumbling. In breaking the large briquettes there was little waste. The briquettes weighed on an average 7.4 pounds each and had a specific gravity of 1.28, the specific gravity of the coal being 1.52. The crushing strength of the briquettes was 17,100 pounds, or 596 pounds to the square inch, this test being made on briquettes that had been exposed to the weather for over a month.

One ton of the anthracite culm was also tested with 7 per cent of pitch D as a binder; but, on account of lack of pressure, the briquettes were porous and not so good as those which contained 7 per cent of pitch B. They stuck together while hot, indicating that 7 per cent of pitch D was sufficient and that an increase of pitch would not improve them. They weighed but 7.06 pounds each on an average.

A 5-ton lot of the anthracite culm was briquetted with 10 per cent of West Virginia coking coal and 11½ per cent of the Hoffman patent binder on the American machine. The eggettes were hard, smooth, and clean, with a somewhat polished surface, and stood considerable rough handling. These eggettes were tested by burning under a boiler, the fire box of which was fitted for a bituminous coal.^a Although made of 79½ per cent of anthracite, they did not burn like anthracite, and their oil and rosin constituents gave a long flame to the fuel, and the boiler ran at 86 per cent of its rated capacity.

From the results of these tests it is apparent that anthracite culm can be satisfactorily briquetted either in combination with a coking coal or by using simply pitch as a binder, and that the briquettes have most of the properties of lump anthracite.

WEST VIRGINIA.

All of the West Virginia coals tested at the plant were good coking coals, so that there was little need of briquetting experiments.

West Virginia No. 3.—A test was made with this coal in the laboratory to determine if it is possible, under a certain pressure and temperature, to make a briquette without any binder. A briquette was obtained which, although not perfectly satisfactory, indicates that under certain conditions, with the right pressure and temperature, briquettes could be made with this coal without any binder whatever. (See p. 1416.)

West Virginia No. 6.—The first test made on this coal was with 5 per cent of the glossy homemade pitch Y. The pressure used was the limit that could be obtained on the English machine, and the resultant briquettes were hard, clean, and strong, and had a sharp, glossy fracture. They were in every way equal to the best briquettes made on this machine. They weighed on an average 6.12 pounds each. On account of the excellent quality of the briquettes with 5 per cent of pitch, another ton was briquetted with only 3 per cent of pitch Y. Extreme pressure was applied, and the resultant briquettes were unusually smooth and glossy, but not quite strong enough. They crumbled instead of cracking clean under the blows of a hammer. The briquettes containing 5 per cent of pitch, when broken, made little or no waste and had a clean fracture.

^a For result of steam test see pp. 793-800.

On the American machine the mixture containing 5 per cent of pitch Y made very glossy and solid eggettes, which were strong and would stand a great deal of rough handling. One surprising quality of these briquettes was that when tested in the cook stove they burned with little or no caking, although the coal itself is a very good coking coal. The briquettes, when exposed to the weather, were affected but little and did not disintegrate appreciably. In burning they held together until entirely consumed.

This coal was also tested with the Hoffman patent binder, and the resultant eggettes were also of good quality, being hard, glossy, and clean; but in burning they caked more than those with 5 per cent of pitch.

WYOMING.

Wyoming No. 1.—This coal was a black, pitchy-looking lignite, which contained 23 per cent of water. It was first tried without drying, 9 per cent of pitch H being used. Judging from the resulting briquette, there was a slight excess of pitch, but on account of the large amount of water in the lignite the pitch apparently failed to adhere to the grains of lignite. The fresh briquettes were difficult to handle, and when broken open the grains of lignite seemed to be coated with moisture, which prevented the pitch from adhering to them. Many of the briquettes were porous, not being sufficiently pressed, and they were also brittle. Some of them, however, were quite good. When broken up and burned in the stove they stood up well in the fire and burned better than any lignite briquette that had thus far been made. They weighed on an average 6.31 pounds each.

Another ton of this lignite was ground in the Williams mill and run through the drier, but this operation removed only a portion of the water, so that the briquette still contained considerable moisture. This material was briquetted on the English machine with 8 per cent of pitch H. A minimum amount of steam was used, which did not contain any excess of water, and a maximum pressure was applied. As received from the machine, many of the briquettes showed perpendicular cracks, due to the excessive pressure. The hot briquettes were difficult to handle, the individual grains of the lignite seeming to be wet and not cohering at all. Many of them would crack badly under their own weight. On breaking open the hot briquettes the grains of lignite seemed to move about as if alive. This lack of cohesion continued until the pitch became quite hard and could no longer be pressed in the machine. Thus the variation in the steam used as the mixture passed through the pug mill had no effect on the cohesion of the briquettes. On cooling, however, these briquettes became very hard and strong and broke with a sharp fracture and with but a small amount of waste. In burning they did not fall to pieces, as did the other lignite briquettes, but burned satisfactorily. They were very light, weighing only 5.85 pounds each, and had a

specific gravity of 0.98. The specific gravity of the coal was only 1.16. The crushing strength of these briquettes was 9,600 pounds, or 339 pounds to the square inch.

Another ton of this coal was tested with a soft, tough asphalt, B6, from Casper, Wyo. As had been shown by laboratory tests, this asphalt could not be used on the English machine alone, and as a result the lignite was briquetted with 5 per cent of asphalt B6, 2½ per cent of rosin, and 1 per cent of lime which had previously been hydrated. This mixture worked perfectly in the machine, and the hot briquettes were firm and good and easily handled, but the proportion of binder was not sufficient and the briquettes were dry and not strong. Another reason for this result was that during the two crushings and dryings of the lignite the grains had become of a nearly uniform size (about 10 mesh), so that the briquettes were very porous in spite of the maximum pressure used. In burning, the briquettes fell to pieces. They weighed on an average 5.40 pounds each. A combination of this coal and asphalt can undoubtedly be obtained which will briquette satisfactorily.

A further test of this lignite was made with 7 per cent of a mixture composed of 20 parts asphalt and 1 part rosin with 1 part slaked lime. The coal had been previously dried. The briquette was poor and disintegrated badly in the fire. This coal was again tried with the same binder without previous drying. This briquette, though better physically, did not have so much cohesion in the fire as the first. It is probable that a partial drying of this lignite would give the best results.

A supply of Wyoming lignite received from Mr. John McNeil, of Casper, Wyo., was briquetted without previous drying with 8 per cent of a mixture composed of 2 parts Wyoming asphalt to 1 part of rosin and 1 per cent of slaked lime. This made a good briquette, which stood up in the fire fairly well, although it disintegrated a little. With 7 per cent of the mixture and 1 per cent of slaked lime the briquette was practically the same; with 6 per cent of the mixture and 1 per cent of slaked lime the briquette was crumbly; while with 7 per cent of the mixture without lime the briquette was physically a little tougher, but disintegrated more in the fire than when the lime was used. On increasing the percentage of lime and using 7 per cent of the mixture and 2 per cent of slaked lime a briquette was obtained that looked much like those made with the 7 to 1 combination, and was not any stronger.

COKE BREEZE.

In order to determine whether it was possible to use waste coke breeze, a series of experiments was made in the laboratory which showed that coke breeze could be briquetted and used as a substitute for lump coke. In order to make a practical test a ton of this mixture was made containing 73 per cent of crushed coke, 20 per cent of

West Virginia No. 6 coal, and 7 per cent of homemade pitch Y. These materials were mixed thoroughly by hand and run through the English machine, both sides of the disintegrator being used. They were well pressed, and as delivered by the machine they were unusually dry and had on the surface a brassy to bronze sheen which looked as though it might be due to an abrasion of the brass of the molds. Upon testing this material, however, it was found to contain only the faintest possible trace of copper. The briquettes were hard and strong and easily handled while hot, but were somewhat dirty. On cooling they became unusually tough and strong, and during combustion were solid and burned more like anthracite than bituminous coal. Such a combination would make a good substitute for anthracite coal. These briquettes weighed on an average 5.73 pounds each.

The same mixture was run through the American machine, and the eggettes were dense, smooth, and polished, but not so tough as the corresponding briquettes. While warm they would stand a great deal of rough handling, but on cooling became brittle. This may be due to the crushing of the coke grains by the excessive pressure obtained in the American machine.

The next test of coke breeze was made without the introduction of any bituminous coal, and the mixture consisted of 92 per cent of coke breeze and 8 per cent of pitch D. In passing this mixture through the English machine both sides of the disintegrator were run, a minimum amount of steam was used, and a moderate pressure was exerted. The resultant briquettes were clean, well formed, and when struck had a metallic ring. They were very tough and strong and would bear much more handling than any of the briquettes made out of the coal. They burned like ordinary coke, without any disintegration and with only a little flame. These briquettes weighed on an average 5.92 pounds each. The well-pressed briquettes had a specific gravity of 1.025 and the porous briquettes had a specific gravity of 1.002. The crushing strength of the better briquettes was 30,100 pounds, or 1,054 pounds to the square inch, while the porous briquettes had a crushing strength of 22,100 pounds, or 784 pounds to the square inch. In comparing the results of the crushing strength of these coke briquettes with those made from coal it will be seen that even the porous briquettes had a much greater crushing strength than the best of the coal briquettes.

The eggettes of this same mixture that were made on the American machine were hard and had the same metallic ring as the briquettes. On account of the fragments of coke being crushed in the press, these were denser than the briquettes, but not so tough. They were, however, satisfactory. The manufacture of these eggettes or briquettes should be a means of utilizing a considerable amount of waste coke.

COKING OF BRIQUETTES AND BRIQUETTE MIXTURES.

In connection with the briquetting of the various coals, a line of experimental work suggested itself, viz, the possibility of making a coke out of a semicoking to non-coking coal by the introduction of sufficient volatile matter in the form of a binder to cause the coal to coke. The first experiment along this line was tried with some of the briquettes made from Arkansas No. 4 coal and 6 per cent of pitch B, by filling a box with about 12 crushed briquettes and then placing this in one of the coke ovens, where it remained during a run of a coking coal. The result of this experiment was the obtaining of a mass of coke which was 12 to 15 inches long, somewhat metallic in appearance, and had a good ring to it. The next experiment was the filling of a box with a mixture of Arkansas No. 4 coal with 6 per cent of pitch B, but without passing it through the press. This was treated in the coke oven like the other, but the results were not so satisfactory as in the first case. A coke was obtained, but it was not so good as the other. The next experiment was with the same mixture after briquetting but without breaking up the briquettes. These were piled on top of one another in a box and tested in the coke oven in the same manner as the other. The result of this test was the obtaining of masses of dense coke that retained the form of the original briquette. All of the coke obtained by these experiments, while not of the quality desired for iron smelting, could be used for lead and copper smelting.

In view of the success attending the above experiments it was decided to try this Arkansas coal on a larger scale, and for this purpose 4 tons of No. 6 slack coal were used. Four tons of this unwashed coal were crushed and mixed with 8 per cent of the hard pitch A and then ground in the Williams mill. Two tons of this mixture were charged direct into a coke oven and the other two tons were briquetted and then placed in the same oven. Both mixtures made coke, but not of the best quality. On account of the briquettes not being packed close together a portion of them were somewhat burned and were not so good as the remainder. The coke was very dark and had large scales. This charge weighed 8,000 pounds, was burned 42 hours and yielded 4,056 pounds of coke and 539 pounds of breeze and ash.

In the following table are given the results of the coking tests of the box of briquettes and the full charge of briquette mixture and briquettes:

Name of sample.	Chemical composition.							Coking time.		Amount produced.			
	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.	Amount charged in oven.	Lbs.	Hours.	Lbs.	Lbs.	Specific gravity.	Percent produced.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.							
Arkansas No. 3:													
Briquettes.....							{ Small box. }		65				
Coke.....	1.05	2.80	72.73	23.42	1.52								
Arkansas No. 6:													
Briquettes.....	4.59	17.25	64.12	14.04	1.68		8,000		42				
Coke.....	4.06	2.77	76.63	16.54	1.43	.050				4,056	539	1.88	50.7

As is seen from the above table, the coke made from Arkansas No. 3 briquettes is high in ash and that made from the Arkansas No. 6 briquettes is also rather high. It must, however, be taken into consideration that these briquettes were made principally from slack unwashed coal. By comparing these results with those of the coking tests on the unbriquetted Arkansas coals, as given on pages 1328-1331, it will be seen that no coke whatever was produced from these Arkansas coals. Mr. Stammer states, however, that if properly washed these coals may make coke in a retort oven.

The above experiments are interesting inasmuch as they show that a naturally noncoking coal may be made to coke by the addition of pitch, which, by increasing the volatile matter, causes the coal to fuse and thus to produce coke. They also seem to show that while a coke can be made by simply mixing the coal and pitch together and charging it into the coke oven, the better quality of coke will be obtained if the mixture has been previously briquetted before being charged into the coke oven; but sufficient experiments along this line have not yet been made to justify any definite conclusions. It is expected, however, that experiments along this line will be continued.

SUMMARY.

From the experimental work that has been carried on at the briquetting plant, it has been fully demonstrated that—

- (1) Some of the American coals, as those from Arkansas, and the slack produced in mining these coals, can be briquetted on a commercial basis.
- (2) In a number of instances the briquetted coal makes a better fuel and will stand transportation better than the original coal.
- (3) It is possible to briquette anthracite culm with pitch without the addition of any bituminous coal, and the briquettes will stand up in the fire without crumbling and burn like a lump of anthracite coal.
- (4) Coke breeze can be briquetted, making a fuel that in burning is similar to an anthracite coal and can bear transportation as well as the coal.
- (5) It is possible by the use of pitch to produce coke from a naturally noncoking coal.

The general results of the work of the briquetting plant are summarized in the table given below:

Summary of briquetting tests.

Name of sample.	Coal.						Binder.			
	Character and condition.	Chemical composition.				Specific gravity.	Per cent.	Kind.	Composition.	
		Volatile matter.	Fixed carbon.	Moisture.	Ash.				Volatile matter.	Fixed carbon.
Alabama No. 1.....		31.84	53.28	2.34	12.54		7	Pitch A.....	47.93	50.79
Arkansas No. 1.....		17.46	66.69	3.24	12.61		9.25	do.....		
Arkansas No. 2.....		16.02	72.55	2.23	9.20		11	Pitch X.....	59.07	39.44
Arkansas No. 3.....	Slightly moist.....	19.47	66.71	2.19	11.63		9.5	do.....		
Do.....	do.....						8.7	Pitch A.....		
Arkansas No. 4.....	Slack.....					1.35	12	Pitch X.....		
Do.....	do.....					1.35	10	Pitch A.....		
Do.....	do.....					1.35	3	Rosin.....		
Do.....	do.....					1.35	2	Pitch A.....		
Do.....	do.....					1.35	3	Rosin.....		
Do.....	do.....					1.35	3	Pitch A.....		
Do.....	do.....					1.35	6	Pitch B.....	49.66	47.88
Do.....	do.....	12.82	73.69	1.28	12.21	1.35	3	Rosin.....		
Do.....	do.....					1.35	2	Pitch B.....		
Arkansas No. 5.....		12.68	72.88	2.36	12.08		6	Pitch C.....	62.75	35.84
Arkansas No. 6.....		13.89	68.50	3.80	13.81		8	Pitch A.....		
Colorado No. 1 ^a		34.88	40.45	18.68	5.99		10	Pitch D.....	54.05	43.91
Illinois No. 1.....	Soft.....	37.48	39.57	9.75	13.20		16	Pitch X.....		
Illinois No. 4.....		31.90	43.55	12.91	11.64	1.34	6	Pitch D.....		
Do.....						1.34	8	do.....		
Do.....	Coarse.....					1.34	8	Pitch E.....	54.11	44.04
Do.....	Fine.....					1.34	8	do.....		
Do.....						1.34	9	do.....		
Do.....						1.34	8	Pitch H.....	61.44	36.72
Do.....						1.34		Asphalt B4.....		
Indiana No. 1.....	Washed.....	35.17	40.41	16.59	7.83		7	Pitch D.....		
Indiana No. 2.....		36.14	41.22	9.62	13.02		7	Pitch H.....		
Indian Territory No. 2.....	Hard.....	36.15	48.40	4.45	11.00		13.4	Pitch X.....		
Indian Territory No. 3.....		37.00	47.25	4.61	11.14		8	Pitch A.....		
Indian Territory No. 6.....	Dirty slack.....	31.28	41.40	8.03	19.29		7	Pitch D.....		
Do.....	do.....						9	do.....		
Do.....	do.....						8	Pitch A.....		
Do.....	do.....						6	Rosin.....		
Do.....	do.....						1	Lime.....		
Do.....	do.....						6	Rosin.....		
Do.....	do.....						1	Petroleum P3.....		
Do.....	do.....						8	Pitch.....		
Do.....	do.....					1.25		Creosote.....		
Do.....	do.....						8	Asphalt B5.....	80.75	19.25
Do.....	do.....						8	Pitch H.....		
Iowa No. 4.....		35.59	39.37	14.08	10.96		7	Pitch E.....		
Do.....							8	do.....		

^a Black lignite.

BRIQUETTING TESTS.

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Summary of briquetting tests—Continued.

Name of sample.	Character and condition.	Coal.						Binder.		
		Chemical composition.						Kind.	Composition.	
		Volatile matter.	Fixed carbon.	Moisture.	Ash.	Specific gravity.	Per cent.		Volatile matter.	Fixed carbon.
Kansas No. 2.....		31.23	46.68	4.18	17.91		11	Pitch X.....		
Kentucky No. 1.....	Good coking.....	36.12	56.39	3.10	4.39		6	Pitch D.....		
Kentucky No. 2.....	Rather hard.....	37.94	45.02	7.91	9.13	1.37	9	Pitch E.....		
Do.....	Slack.....					1.37	8	do.....		
Missouri No. 1.....	Washed.....	33.58	38.73	8.33	19.36		11.5	Pitch A.....		
Montana No. 1.....	do.....	35.90	42.08	11.05	10.97		16	do.....		
Do.....	do.....						7	Pitch B.....		
New Mexico No. 1 ^a		34.58	46.14	12.29	6.99		12	Pitch A.....		
Do.....							15.8	Pitch X.....		
Do.....							8	Pitch D.....		
Do.....							10	do.....		
Do.....							8	Pitch H.....		
New Mexico No. 2 ^a	Slack.....	33.82	36.73	10.79	18.66		7	Pitch D.....		
Do.....	do.....						9	do.....		
North Dakota No. 1 ^b	Tough; not dry ..	29.59	25.68	35.38	9.35		10	Pitch A.....		
Do.....	Dry.....						12	do.....		
Pennsylvania No. 3.....	Anthracite culm..	7.02	71.79	5.41	15.78	1.52	12.5	Pitch A.....		
Do.....	Culm.....					1.52	8.75	West Virginia coal.		
Do.....	Culm, dried.....					1.52	7	Pitch B.....		
Do.....							9	West Virginia coal.		
West Virginia No. 6.....		21.54	71.88	1.53	5.05		5	Pitch Y.....		
Do.....							3	do.....		
Wyoming No. 1 ^a		35.68	37.19	22.63	4.50	1.16	9	Pitch H.....		
Do.....	Dried.....					1.16	8	do.....		
Do.....	do.....					1.16	5	Asphalt B6.....		
							2.5	Rosin.....	78.77	20.75
							1	Lime.....		

^a Black lignite.^b Brown lignite.

Summary of briquetting tests—Continued.

Name of sample.	Briquettes.					Crushing strength, pounds per square inch.
	Specific gravity.	Weight in pounds.	General character.	Behavior on weathering.	Behavior on burning.	
Alabama No. 1.....		5.12	Good.....	Slightly disintegrates.	Good.....	
Arkansas No. 1.....			Poor, friable.....	Disintegrates.	Poor.....	
Arkansas No. 2.....			Poor, porous.....	Poor.....		
Arkansas No. 3.....		6.8				
Do.....			Very good, smooth and hard	Good.....	Held together until consumed.	
Arkansas No. 4.....			Incoherent.....	Disintegrates.		
Do.....		6.47	Good, compact.....	Good.....		
Do.....		6.87	Clean, compact, but brittle.	do.....	Some smoke, very good.	
Do.....	1.13	6.87	Clean, excellent.....	do.....	Burn readily, no disintegration.	306
Do.....	1.17	6.92	Excellent in every respect.	No deterioration.	No disintegration.....	610
Do.....		7.20	Tender, friable.....			
Colorado No. 1 ^a		5.98	Hard and lustrous, but brittle.	Slight deterioration.	Satisfactory, little disintegration.	
Illinois No. 1.....			Like pressed damp loam.			
Illinois No. 4.....	1.16	6.95	Hard, but rather friable.....		Some disintegration.....	181
Do.....	1.11	6.43	Hard and tough.....	Good.....	Good.....	325
Do.....	1.13	6.15	Not well pressed; somewhat porous.		Fair.....	253
Do.....	1.03	6.50	Well pressed, but friable.....	Fair.....	do.....	209
Do.....	1.08	6.43	Good.....	do.....	Good.....	352
Do.....	1.11	6.81	Clean, excellent.....	Good.....	Very satisfactory.....	446
Do.....		6.77	Tough, fair.....			
Indiana No. 1.....		6.80	Very good.....	Good.....	Very satisfactory.....	
Indiana No. 2.....		6.42	Clean, excellent.....	do.....	do.....	
Indian Territory No. 2.....		6.15	Poor.....	Crumbles.....	Poor.....	
Indian Territory No. 3.....		6.56	Fair.....	Disintegrates.	Fair.....	
Indian Territory No. 6.....	1.205	7.35	Dense, but crumbly.....	do.....	Disintegrates.....	195
Do.....		7.50	do.....	do.....	do.....	
Do.....			do.....	do.....	do.....	
Do.....		7.00	do.....	do.....	do.....	
Do.....	1.25	7.29	Strong, good.....		Good, considerable smoke.	223
Do.....	1.215	7.25	Good, crumbles slightly.....		Good.....	226
Do.....	1.22	7.12	Tough, good.....		do.....	111
Do.....		7.27	Very good.....		Very good.....	
Iowa No. 4.....		6.73	Crumbles.....	Poor.....	Fair.....	
Do.....		6.77	Strong, but not quite hard enough.	Good.....	Very good, no disintegration.	

^a Black lignite.

Summary of briquetting tests—Continued.

Briquettes.						
Name of sample.	Specific gravity.	Weight in pounds.	General character.	Behavior on weathering.	Behavior on burning.	Crushing strength, pounds per square inch.
Kansas No. 2.....			Poor.....	Poor.....	Poor.....	
Kentucky No. 1.....		6.15	Good, slightly porous.....	Very good.....	Excellent.....	
Kentucky No. 2.....		6.83	Very hard and tough.....	do.....	do.....	
Do.....	1.13	6.83	Excellent.....	do.....	do.....	394
Missouri No. 1.....			Pitch set too quick, porous.....	Fair.....	Good.....	
Montana No. 1.....		6.30	Fair, rather porous.....	Good.....	do.....	
Do.....		7.00	Hard, but brittle.....	do.....	do.....	
New Mexico No. 1 ^a			Very unsatisfactory.....	Crumbles.....	Disintegrates.....	
Do.....			Poor.....	do.....	do.....	
Do.....	1.13	6.83	Fair, somewhat crumbly.....	do.....	do.....	248
Do.....	1.02	6.42	do.....	do.....	do.....	206
Do.....	1.06	6.25	Hard and strong.....	Good.....	Good.....	454
New Mexico No. 2 ^a		7.00	Crumbly.....	Disintegrates.....	Disintegrates.....	
Do.....		7.12	Earthy.....	Fair.....	Fair.....	
North Dakota No. 1 ^b			Porous, little cohesion.....	Disintegrates.....	Disintegrates.....	
Do.....			do.....	do.....	do.....	
Pennsylvania No. 3.....		7.25	Hard and tough, good.....	Becomes pitted.....	Good, like anthracite.....	
Do.....	1.174	7.64	Fair.....	do.....	do.....	156
Do.....	1.28	7.40	Hard and strong.....	Good.....	do.....	596
West Virginia No. 6.....		6.12	Very good.....	Very good.....	Very good.....	
Do.....			Good.....	Good.....	Good.....	
Wyoming No. 1 ^a		6.31	Fair, porous.....	Fair.....	Satisfactory.....	
Do.....	.98	5.85	When cold, hard and strong.....	Good.....	Good.....	339
Do.....		5.40	Poor.....	Fair.....	Fell to pieces.....	

^a Black lignite.

^b Brown lignite.

WASHING TESTS.

By JOHN D. WICK.

INTRODUCTION.

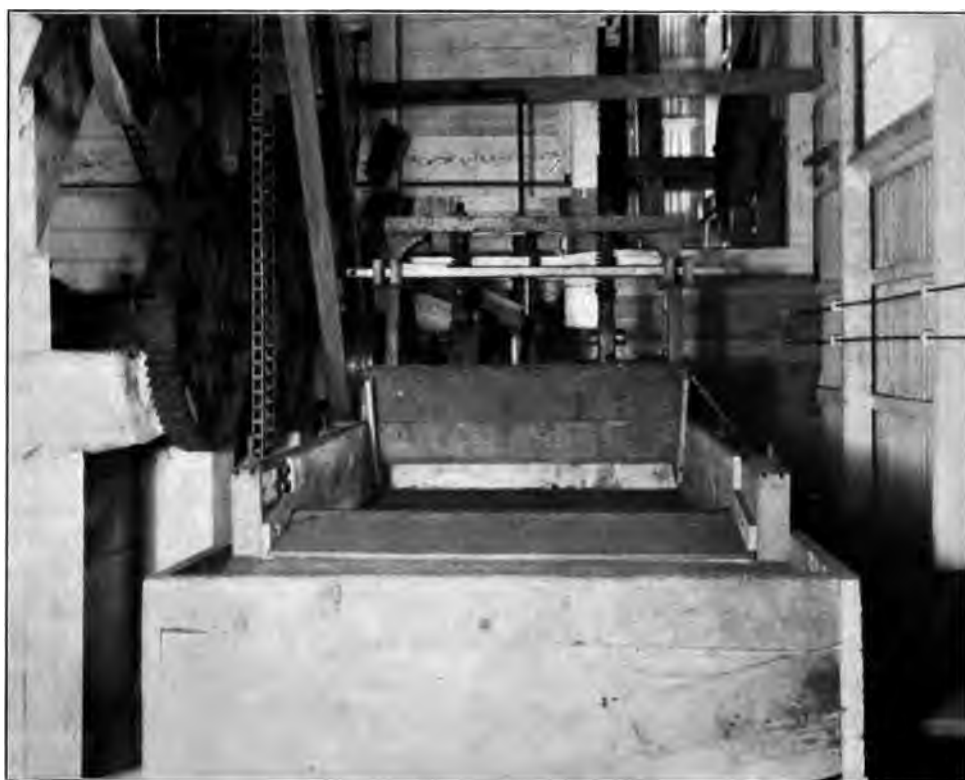
The washery plant was constructed after designs furnished by Roberts & Shaefer Company, of Chicago. It was under the immediate supervision of the writer, who was assisted by Mr. Edward Moore. The chemical analyses given in the report were made at the laboratory of the testing plant under the direction of Prof. N. W. Lord. The steam tests mentioned were made in the boiler room under the direction of Prof. L. P. Breckenridge.

Owing to the small appropriation and the great cost of all material and labor on the Exposition grounds, the washery plant was made as small as possible, consisting of four 35-ton storage bins and two bins of half the size for holding material to be washed. On account of the small size of the bins holding material to be washed, it was impossible to wash an entire carload of coal in one operation. Washing tests, therefore, had to be made in lots of 10 tons or less, and for that reason the best results were not always obtained and not many such tests were made. The lack of adequate storage facilities and the constant demand upon the conveying apparatus for supplying fuel to the boiler room, the gas-producer plant, the coke ovens, and the briquetting machines made it frequently impossible to weigh carefully the washed product and the refuse material. Although complete washing tests were made in only a few instances, considerable coal was washed for coking, but in small amounts, only sufficient for charging a single oven.

As noted in the general description of the plant (p. 25), the washing apparatus consisted of a New Century jig and a modified Stewart jig (see Pl. XIII). The former is designed for washing very fine material, whereas the latter will wash coal composed of pieces crushed to a diameter of $1\frac{1}{2}$ inches. The tests made were not sufficiently complete to determine the efficiency of these jigs, but considerable difficulty was experienced with the New Century jig, the material being so fine that it packed in the bottom of the jig and thus prevented the discharge of the refuse material. The modified Stewart jig gave very good satisfaction, and seems very well adapted to most kinds of coal.



A. STEWART JIG.



B. NEW CENTURY JIG.

SPECIAL TESTS.

Complete washing tests were made upon the samples named below, and with the results stated.

ILLINOIS No. 2.

This sample consisted of a carload of slack from the O'Fallon mine of the Western Anthracite Coal and Coke Company, near O'Fallon, Ill. The coal in this district produces considerable slack, which finds a fairly ready market in St. Louis, but the price received is hardly sufficient to pay for transportation. Washing has been introduced at a number of plants to improve the quality of the slack, with promising results, and this test was made with the object of determining what improvement could be effected in this particular part of the district. The slack washed consisted of 27,280 pounds, which was carefully sampled before and after washing.

This coal was washed in the modified Stewart jig. The weight of the washed coal was not ascertained, but the refuse weighed 3,520 pounds.

The first column of the appended table shows the composition of the raw coal as far as its content of moisture, ash, and sulphur is concerned. The second column gives the same data for the washed coal and the third column for the refuse.

Analyses of Illinois No. 2 coal and refuse, showing effect of washing.

	Raw coal.	Washed coal.	Refuse.
Moisture per cent.	12.03	19.07	15.99
Ash do.	22.44	9.42	53.08
Sulphur..... do.	4.00	3.35	9.06
Weight..... pounds.	27,280		3,520

A comparison of these figures shows that the percentage of ash was reduced from 22.44 to about 9.42 by washing, but the greater amount of moisture in the washed-coal sample makes direct comparison impossible. If the analysis of the washed coal had been determined on the same basis as that of the raw coal, the percentage of ash in the latter would be about 10 per cent. This shows a reduction of fully 12 per cent in ash as a result of washing a small lot through the Stewart jig, but washing on a commercial scale might improve this result considerably.

The sulphur shows a slight reduction, about one-half of 1 per cent. It would seem from these figures either that the major portion of the sulphur is so intimately combined with the coal as to be inseparable from it, or that the sulphur is present in thin flakes which pass over with the coal.

The next important item in successful washing is the determination of the amount of coal retained in the refuse, or, in other words, wasted. From the composition of the refuse and its weight the amount of coal in the refuse is about 1,000 pounds, about 3½ per cent of the original charge, or about 5½ per cent of the coal in the original charge.

The effect of washing in improving the quality of this coal is shown by steam tests Nos. 18 and 19. Test No. 18 was made on lump coal from this mine, and test No. 19 was made on the washed slack from the same mine.

The following brief results of these tests are given:

Steam tests of lump and washed coal (Illinois No. 2).

Coal tested.	Total coal consumed.	Horse-power developed by boiler.	Dry coal burned per square foot of grate surface, per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horse-power hour.	Dry coal per electrical horse-power hour.
	Pounds.		Pounds.	Pounds.	Pounds.	Pounds.
Lump coal.....	11,124	211.4	24.90	7.21	3.92	4.85
Washed slack.....	10,096	210.2	22.36	8.00	3.54	4.38

A small amount of this coal was also washed for coking purposes, and the improvement may be noted by comparing the results obtained from this charge with those obtained from a charge of Illinois No. 1, which consists of lump coal from the same mine. This test was made on a charge of 9,000 pounds of unwashed coal, which was burned for 43 hours. It produced some small pieces of coke mixed with charred coal and ash. This coal contained 15.95 per cent of ash and, possibly for this reason in part, failed to coke.

The second test was made on Illinois No. 2 washed. The amount of coal charged was 9,000 pounds, which, after burning 64 hours, yielded 3,389 pounds of mixed hard and soft coke and 352 pounds of breeze and ash.

From this report it is obvious that the raw lump coal did not coke, but the washed slack produced coke of fair quality, although the percentage of the yield is so small that it probably would not be commercially successful.

The improvement by washing is also shown by the chemical analyses of the coal before and after washing, as follows:

Analyses showing effect of washing Illinois No. 2 coal.

	Raw coal.	Washed coal for coking.
Ash.....per cent..	22.44	9.19
Sulphur.....do....	4.00	3.03

INDIANA No. 1.

This was a sample of run-of-mine coal from the mine of the J. Woolley Coal Company, located at Mildred, Sullivan County, Ind. No washing is now done in this district, but the coal contains considerable impurity, and the operators are very desirous of obtaining information concerning the effectiveness of washing operations.

The charge, consisting of 15,250 pounds of run-of-mine coal, was passed through rolls having an aperture of 1½ inches, and then washed through the modified Stewart jig.

After the coal was crushed it was sampled and analyzed, giving the figures shown in the column marked "Raw coal" in the accompanying table. After washing it was again sampled and analyzed, and the results are given in the second column of the table. The refuse was also sampled and analyzed, with the results shown in the third column.

Analyses of Indiana No. 1 coal and refuse, showing effect of washing.

	Raw coal.	Washed coal.	Refuse.
Moisture.....per cent..	11.40	16.72	14.85
Ash.....do.....	13.40	7.16	31.71
Sulphur.....do.....	2.50	2.23	5.68
Weight.....pounds..	15,250	12,620	3,485
Coal.....do.....	11,468	9,600	1,860

The results of this test are not so satisfactory as that of Illinois No. 2, but it is probable that equally good results could be obtained by further trials.

The test of Indiana No. 1 is satisfactory as far as the reduction of the impurities is concerned, but it is not satisfactory when it is considered that about 1,860 pounds of coal (exclusive of moisture and ash) passed over with the refuse matter. This is probably too great a loss for commercial success, but, as noted above, there is every reason to believe that washing could be done that would result in a much cleaner coal and at the same time lose but little coal with the refuse material.

A steam test was made of this coal after washing, but no test was made on the raw coal, so it is impossible to say how great the improvement was except from the chemical analyses. The steam test on the washed coal is given in test No. 68, page 481.

A washing test was also made on about 4½ tons of this coal for coking purposes. No test was made in the coke ovens of the raw coal; hence the coke

produced can not be compared, but the chemical analyses show the improvement effected, as follows:

Analyses of Indiana No. 1 coal, showing effect of washing.

	Raw coal.	Washed coal for coking.
Ash.....per cent.	13. 40	7. 04
Sulphur.....do.	2. 50	2. 03

MISSOURI No. 3.

This sample consisted of a carload of slack from the Mendota Coal and Mining Company, operating at Mendota, Putnam County, Mo. Like most of the coals from northern Missouri and southern Iowa, this coal contains a large percentage of impurities, and the operators are desirous of improving their product. It was for this reason that the above test was undertaken, as the results of this test will doubtless apply to the entire field in Putnam County, Mo., and Appanoose County, Iowa.

The sample, consisting of 14,000 pounds of slack, was passed through rolls having an aperture of 1½ inches, and then washed through the modified Stewart jig. After the coal was crushed it was sampled and analyzed, giving the figures shown in the column marked "Raw coal" in the accompanying table. After washing, it was again sampled and analyzed, with the results given in the second column of the table. The refuse was also sampled and analyzed, with the results shown in the third column.

Analyses of Missouri No. 3 coal and refuse, showing effect of washing.

	Raw coal.	Washed coal.	Refuse.
Moisture.....per cent.	14. 37	23. 90	23. 38
Ash.....do.	28. 39	7. 59	36. 70
Sulphur.....do.	4. 30	2. 89	3. 94
Weight.....pounds.	14, 000		4, 931
Calculated weight of coal.....do.	8, 013	6, 045	1, 968

The refuse weighed 4,931 pounds. It appears from the chemical analysis that the raw coal contained 8,013 pounds of coal, exclusive of moisture and ash, and the refuse 1,968 pounds. The washed coal, therefore, must have been the difference, or 6,045 pounds.

The results given above show great improvement. The slack was extremely dirty, as the analysis shows. Washing reduced the ash from 28.39 per cent in

the raw coal to 7.59 per cent in the washed coal. The sulphur was likewise reduced from 4.30 to 2.89 per cent. On the whole, the reduction in the impurities is highly satisfactory, but the amount of coal lost in the operation (1,968 pounds) is too great for economical work. It is possible that better results might have been obtained if the tests had been continued, but enough has been done to show that great improvement may be made in the quality of the slack coal in this field by washing.

The improvement in washing this slack was still further tested by steam tests made on the raw coal and also on the washed product.

Steam tests showing effect of washing Missouri No. 3 coal.

Coal tested.	Total coal consumed.	Horse-power developed by boiler.	Dry coal burned per square foot of grate surface, per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horse-power hour.	Dry coal per electrical horse-power hour.
	Pounds.		Pounds.	Pounds.	Pounds.	Pounds.
Raw slack.....	10,828	149.5	21.85	5.82	4.86	6.00
Washed slack.....	11,044	189.7	21.72	7.43	3.81	4.70

A washing test was also made of about 6½ tons of this coal for coking purposes. No trial was made of the raw coal in the oven, so it is impossible to make a direct comparison of the coke, but the chemical analyses give some idea of the improvement produced.

Analyses showing effect of washing Missouri No. 3 coal.

	Raw coal.	Washed coal for coking..
Ash.....per cent..	28.39	7.24
Sulphur.....do....	4.30	2.74

GENERAL TESTS.

In addition to the above-mentioned special tests, a great many charges of coal for the coke ovens were washed, and generally with fairly satisfactory results, considering the small amount of coal in each charge.

As previously stated, the congested condition of the conveying apparatus prevented the weighing of any of these small charges after washing, but some idea of the effects of washing may be gained by comparing the chemical analyses made before and after washing and by noting the character of coke produced when tests were made on washed and unwashed material. The amounts stated in the analyses are percentages.

ALABAMA No. 1.

Lump coal from mine No. 8, Ivy Coal and Iron Company, Horse Creek, Ala.

Coking tests were made of both washed and unwashed coal from this mine. The first charge of unwashed coal consisted of 8,000 pounds. Although the coking process was continued for 88 hours, the coke was very light and spongy and high in ash. Washing reduced the percentage of impurities but slightly, though it is believed that with more thorough washing a coke of good quality might be obtained.

Analyses showing effect of washing Alabama No. 1 coal.

	Raw coal.	Washed coal for coking.
Ash.....	13.88	11.06
Sulphur.....	.76	.89

ARKANSAS No. 6.

Slack coal from mine No. 18, Western Coal and Mining Company, Jenny Lind, Ark.

About 5 tons of this coal were washed for coking purposes. No coke was produced, but the chemical analyses show improvement.

Analyses showing effect of washing Arkansas No. 6 coal.

	Raw coal.	Washed coal for coking.
Ash.....	13.81	6.22
Sulphur.....	1.26	1.22

ILLINOIS No. 3.

Run-of-mine coal from mine No. 3, Southern Illinois Coal Mining and Washing Company, Marion, Ill.

Two coking tests were made of this coal, one of raw coal and the other of coal washed for the purpose. These tests permit direct comparison, and the effect of washing is plainly apparent. The unwashed charge of 9,000 pounds was tested for 43 hours. The coal lay dead in the oven, burning on top, but did not coke. In the second test the charge (washed) consisted of 13,000 pounds and was burned 90 hours, yielding 6,378 pounds of coke, which was very brittle and which broke up in handling into fine-fingered pieces.

The chemical composition of the two grades of coal is shown below:

Analyses showing effect of washing Illinois No. 3 coal.

	Raw coal for coking.	Washed coal for coking.
Ash.....	10. 59	5. 86
Sulphur.....	1. 45	1. 41

ILLINOIS No. 5.

No. 5 washed slack from mine No. 1, Donk Brothers Coal and Coke Company, Collinsville, Ill.

The slack at this plant is washed and divided into five grades, and the sample consisted of No. 5, or the smallest size produced. The particles of coal were all less than one-fourth inch in diameter. The coal was washed at the mine, but owing to the overcrowded condition of the washery this grade of coal carried a considerable amount of impurities, mainly as a clay coating on the particles of coal. As the coal did not coke in the condition received, a charge consisting of about 6 tons was rewashed in the New Century jig. The coal was extremely wet when charged, chilling the oven, and no coke was produced. Although the coking test was not successful, the rewashing showed a distinct gain in the quality of the coal, but considerable coal was lost in the operation. Chemical analyses show the following results:

Analyses showing effect of washing Illinois No. 5 coal.

	First charge washed.	Second charge re-washed.	Third charge washed.
Ash.....	17. 56	9. 18	18. 16
Sulphur.....	3. 25	2. 71	3. 44

INDIAN TERRITORY No. 2.

Run-of-mine coal from mine No. 8, Rock Island Coal Company, Hartshorne, Ind. T.

Tests were made on this coal in the raw state and also after washing. The unwashed charge (9,000 pounds) was burned for 66 hours and yielded 5,725 pounds of coke and 580 pounds of breeze and ash. The coke was soft, shattered, and brittle. The washed charge was burned for 65 hours, producing a coke which had a fairly good ring. It showed considerable improvement in appearance over

the coke made from unwashed coal. The change in the impurities is shown by the following analyses:

Analyses showing effect of washing Indian Territory No. 2 coal.

	Coal.		Coke.	
	Raw.	Washed.	From raw coal.	From washed coal.
Ash.....	9.99	6.33	14.43	11.12
Sulphur.....	1.47	1.43	1.50	1.75

INDIAN TERRITORY NO. 3.

Run-of-mine coal from mine No. 1, D. Edwards & Sons, Edwards, Ind. T.

Coking tests were made on this coal in both the raw and the washed condition, but the washing does not appear to have been successful in reducing materially either the sulphur or the ash. No coke was made from either charge. The amount of impurities is shown in the following table:

Analyses showing effect of washing Indian Territory No. 3 coal.

	Raw coal for coking.	Washed coal for coking.
Ash.....	9.75	7.49
Sulphur.....	3.16	3.20

INDIAN TERRITORY NO. 5.

Slack and pea coal from mine No. 7, Western Coal and Mining Company, Lehigh, Ind. T.

About 5 tons of this slack were washed for a coking test, but without satisfactory results so far as the production of coke is concerned. The improvement effected by washing is shown in the following analyses:

Analyses showing effect of washing Indian Territory No. 5 coal.

	Car sample.	Washed coal for coking.
Ash.....	25.05	8.14
Sulphur.....	3.95	2.90

WASHING TESTS.

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IOWA No. 1.

Lump and fine coal from mine No. 2, Anchor Coal Company, Laddsdale, Iowa.

About 5 tons of this coal were washed for a coking test, but the coal was not tried in a raw condition, and consequently the coking test affords no clue to the improvement made by washing. The change is shown by the chemical analyses.

Analyses showing effect of washing Iowa No. 1 coal.

	Car sample.	Washed coal for coking.
Ash.....	16. 0	10. 25
Sulphur.....	5. 03	4. 61

IOWA No. 2.

Run-of-mine coal from mine No. 6, Mammoth Vein Coal Company, Hamilton, Iowa.

About 5½ tons of coal were washed for a coking test. The reduction of impurities effected by washing was not great, as shown by the following analyses:

Analyses showing effect of washing Iowa No. 2 coal.

	Car sample.	Washed coal for coking.
Ash.....	15. 22	10. 28
Sulphur.....	4. 66	3. 93

IOWA No. 3.

Lump coal from mine No. 4, Gibson Coal Mining Company, Altoona, Iowa.

About 4½ tons of this coal were washed for a coking test. The improvement in the quality of the coal effected by washing is shown in the following analyses:

Analyses showing effect of washing Iowa No. 3 coal.

	Car sample.	Washed coal for coking.
Ash.....	14. 01	8. 03
Sulphur.....	6. 15	4. 55

IOWA No. 4.

Lump coal from mine No. 3, Centerville Block Coal Company, Centerville, Iowa.

A charge consisting of about 4½ tons of this coal was washed for coking purposes. The results were not so satisfactory as those obtained on other samples from this State. The analyses are given below:

Analyses showing effect of washing Iowa No. 4 coal.

	Car sample.	Washed coal for coking.
Ash.....	10. 96	7. 14
Sulphur.....	4. 26	3. 59

IOWA No. 5.

Run-of-mine coal from mine No. 1, Inland Fuel Company, Chariton, Iowa:

A charge consisting of nearly 5 tons of this coal was washed for a coking test, but the coal did not coke, although the washing was fairly successful in reducing the impurities, as shown by the following analyses:

Analyses showing effect of washing Iowa No. 5 coal.

	Car sample.	Washed coal for coking.
Ash.....	12. 63	7. 93
Sulphur.....	3. 19	2. 28

KENTUCKY No. 3.

Run-of-mine coal from Barnsley mine, St. Bernard Mining Company, Earl-
ington, Ky.

A charge of about 5½ tons of this coal was washed for coking purposes. It produced a coke of fair quality, although only a slight reduction was made in the impurities by washing. The analyses are as follows:

Analyses showing effect of washing Kentucky No. 3 coal.

	Car sample.	Washed coal for coking.
Ash.....	10. 06	7. 40
Sulphur.....	3. 52	2. 51

KENTUCKY No. 4.

Run-of-mine coal from Wheatcroft Coal and Mining Company, Wheatcroft, Ky.

A charge of about 5½ tons of this coal was washed for a coking test. Washing was very much more successful in this case than in that of the other coal from Kentucky. The change is shown in the following table:

Analyses showing effect of washing Kentucky No. 4 coal.

	Car sample.	Washed coal for coking.
Ash.....	14. 18	6. 05
Sulphur.....	4. 54	2. 74

MISSOURI No. 2.

Run-of-mine coal from mine No. 8, Northwestern Coal and Mining Company, Bevier, Mo.

A charge of about 6½ tons of this coal was washed for a coking test, with the following result:

Analyses showing effect of washing Missouri No. 2 coal.

	Car sample.	Washed coal for coking.
Ash.....	16. 86	7. 76
Sulphur.....	5. 16	3. 24

WEST VIRGINIA No. 2.

Run-of-mine coal from Pitcairn mine, Pitcairn Coal Company, Clarksburg, W. Va.

Two coking tests were made on this sample, one of raw coal and one of washed coal. This affords an additional means of judging of the effectiveness of washing, for the coke shows improvement in the second (washed-coal) test, which can be accounted for only by better quality of coal. The following table shows the results:

Analyses showing effect of washing West Virginia No. 2 coal.

	Coal.		Coke.	
	Raw.	Washed.	From raw coal.	From washed coal.
Ash.....	8. 22	7. 05	14. 95	11. 40
Sulphur.....	3. 38	2. 84	3. 40	2. 24

WEST VIRGINIA No. 3.

Run-of-mine coal from West Virginia Coal Company, Richard, W. Va.

This coal was tested in the coke ovens in both the raw and the washed condition, and a comparison of results shows that washing as done in this test had little effect. The charge that was washed weighed about 7½ tons.

Analyses showing effect of washing West Virginia No. 3 coal.

	Coal.		Coke.	
	Raw.	Washed.	From raw coal.	From washed coal.
Ash.....	9.75	9.01	18.18	14.27
Sulphur.....	.99	1.12	.93	1.19

WEST VIRGINIA No. 4.

Run-of-mine coal from West Virginia Coal Company, Bretz, W. Va.

Two coking tests were made of this coal, one in the raw and one in a washed condition. The charge that was washed weighed about 5 tons. The results of these tests, as shown by the analyses of the coal and the coke, are not in harmony, so it is difficult to determine the effect of washing.

The analyses are as follows:

Analyses showing effect of washing West Virginia No. 4 coal.

	Coal.		Coke.	
	Raw.	Washed.	From raw coal.	From washed coal.
Ash.....	8.39	7.53	11.85	13.23
Sulphur.....	.86	.74	.82	.69

The change in the amount of impurities is so slight that the irregularities of sampling are probably responsible for the difference in the figures.

WEST VIRGINIA No. 5.

Lump and nut coal from mine of Davis Colliery Company, Coalton, W. Va.

Three coking tests were made of this coal, to determine the possibility of reducing the ash to within the limit of coke for blast-furnace use. The first charge consisted of about 6½ tons of raw coal; the second charge contained about 7 tons of coal crushed in rolls to 1½ inches in size and then washed; the third charge contained about 5½ tons of coal, which was pulverized in the Williams mill and washed in the New Century jig. The results of washing are shown by the following analyses:

Analyses showing effect of washing West Virginia No. 5 coal.

	Coal.			Coke.		
	Raw.	Washed.	Pulverized and washed.	From raw coal.	From washed coal.	From pulverized and washed coal.
Ash.....	10. 73	10. 28	8. 19	19. 14	14. 81	15. 98
Sulphur.....	. 90	. 91	. 79	. 77	. 83	. 82

WEST VIRGINIA NO. 9.

Run-of-mine coal from Vulcan mine, Mount Carbon Coal Company (Limited), Powellton, W. Va.

This coal was tested in the coke ovens, in both the raw and the washed condition. The charge of raw coal contained about 4½ tons and that of washed coal about 6 tons. The coke from the washed coal showed much improvement over that from the unwashed coal. The change in composition is shown by the following analyses:

Analyses showing effect of washing West Virginia No. 9 coal.

	Coal.		Coke.	
	Raw.	Washed.	From raw coal.	From washed coal.
Ash.....	8. 07	4. 51	9. 15	7. 38
Sulphur.....	. 83	. 90	. 82	. 77

WEST VIRGINIA NO. 12.

Run-of-mine coal from mine of the Big Sandy Coal and Coke Company, Big Sandy, W. Va.

Two coking tests were made of this coal, one of raw coal and one of washed coal. The first charge consisted of about 5½ tons of coal and the second charge of about 4½ tons. No particular change was noted in the coke made from the two grades of coal, but the analyses show a reduction of ash, as follows:

Analyses showing effect of washing West Virginia No. 12 coal.

	Coal.		Coke.	
	Raw.	Washed.	From raw coal.	From washed coal.
Ash.....	6. 16	4. 90	9. 43	7. 55
Sulphur.....	. 97	1. 11	. 83	1. 01

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